JOURNAL OF ENERGY, MATERIAL, AND INSTRUMENTATION TECHNOLOGY

Journal Webpage https://jemit.fmipa.unila.ac.id/

Smart Green Box Trash Design Based on HC-SR04 Sensor Arduino Uno Integrated

Mahardika Setiawan Dika*, Sri Wahyu Suciyati, Amir Supriyanto, and Gurum Ahmad Pauzi

Department of Physics, University of Lampung, Bandar Lampung, Indonesia, 35141

Article Information

Article history:
Received January 27, 2022
Received in revised form February 17, 2022
Accepted August 13, 2023

Keywords: *Arduino Uno, HC-SR04, LCD, Servo, DFPlayer*

Abstract

This research has realized the design of a smart green trash box based on the HC-SR04 sensor, which is integrated with Arduino Uno. This research aims to design and build a digital instrumentation system based on Arduino Uno, applying Ultrasonic Sensors to the Green Box Trash System. In addition, this system is equipped with an information display via LCD and speakers so that we can find out the contents of the green trash box. Data retrieval by detecting objects with a distance of less than 10 cm to open the trash and measure the volume in the green trash box. The research results are displayed as a prototype Smart Green Trash Box design. Based on the Hc-Sr04 Sensor Integrated by Arduino Uno. The ultrasonic sensor in the Green Box Trash system works well by measuring the volume and can detect when an object is approaching with a distance of less than 10 cm. Assembling the green box using the HC-SR04 sensor, which is integrated with Arduino Uno functions according to the program created if, in the green box, there is HC-Sr04 1 sensor trash, it measure the volume of trash and then display it through the LCD, and if there is an object approaching the HC-Sr04 sensor 2, then the servo moves so that the green trash box can be opened. The Green Trash box can display trash volume and time on the 16x2 character LCD in real-time with the program uploaded to Arduino as monitoring.

Informasi Artikel

Proses artikel:
Diterima 27 Januari 2022
Diterima dan direvisi dari 17 Februari 2022
Accepted 13 Agustus 2023

Kata kunci: Arduino Uno, HC-SR04, LCD, Servo, DFPlayer

Abstrak

Penelitian ini telah merealisasikan rancang bangun smart green box sampah berbasis sensor hc-sr04 yang terintegrasi arduino uno. Tujuan penelitian ini adalah untuk merancang dan membangun sistem instrumentasi digital tempat sampah berbasis arduino uno, Mengaplikasikan Sensor Ultrasonik pada sistem green box sampah. selain itu, sistem ini dilengkapi dengan tampilan informasi melalui LCD dan speaker sehingga dapat mengetahui isi green box sampah. Pengambilan data dengan mendeteksi objek dengan jarak kurang dari 10 cm untuk membuka tempat sampah dan mengukur volume pada green box sampah. Hasil penelitian ditampilkan dalam bentuk prototipe Rancang Bangun *Smart Green Box* sampah Berbasis Sensor Hc-Sr04 yang Terintegrasi Arduino Uno. Sensor ultrasonik pada sistem *Green Box* sampah berjalan dengan baik dengan mengukur volume dan dapat mendeteksi ketika ada sebuah objek mendekat dengan jarak kurang dari 10 cm. Perakitan *Green Box* menggunakan sensor HC-SR04 yang terintegrasi Arduino Uno berfungsi sesuai dengan program yang dibuat, apabila di dalam *Green Box* terdapat sampah sensor HC-Sr04 1, maka akan mengukur volume sampah kemudian ditampilkan melalui LCD dan apabila ada sebuah objek mendekati sensor HC-Sr04 2, maka servo bergerak sehingga *green box* sampah dapat terbuka. *Green box* Sampah dapat menunjukan tampilan volume sampah dan waktu pada LCD karakter 16x2 secara *real time* dengan program yang di unggah pada arduino sebagai monitoring.

* Corresponding author.
E-mail address: mahardikasetiawan444@gmail.com

1. Introduction

Trash processing in Indonesia is an actual problem, along with the increasing population growth rate, which produces an increasing amount of trash.

Several studies have analyzed the causes of problems in Indonesia's trash management. Chaerul et al. (2007) analyzed that the problems encountered in inadequate trash management are the lack of effort in composting and the lack of TPA management with the right system. Kardono., (2007) states that trash management in Indonesia is seen from several indicators, such as the high amount of trash produced, the lack of trash processing levels, and the lack of landfills.

According to Amurwahaja., (2007), to determine alternative trash processing technologies, four aspects need to be considered, namely social, economic, environmental, and technical. Several studies related to trash management, namely, Sayfudin et al. (2018) manage trash with the Wireless sensor r network (WSN) system measuring the volume of trash and street lighting. The drawback of the WSN is that the output only provides information to the cleaning staff. Furthermore, Sukarjadi et al. (2017) manage trash with the smart trash bin system to measure the volume of trash. The drawbacks of this research are the outputs in the form of LEDs and buzzers.

The trash can's volume is the space in the trash can. When the trash has filled the space in the trash can, it will be said to be full. It is still much weakness because people still throw much trash into the trash even though the space in the trash can is full, so the trash can not last long term and does not look neat. Then a measurement of the volume of trash is made so that the trash can be used long-term and beautifies the environment.

This research was carried out by an innovation in the design of environmentally friendly trash cans (green trash boxes). The tool's design is based on Arduino, which is integrated with an ultrasonic sensor to measure the height of the trash in the box, with output using an LCD and speaker.

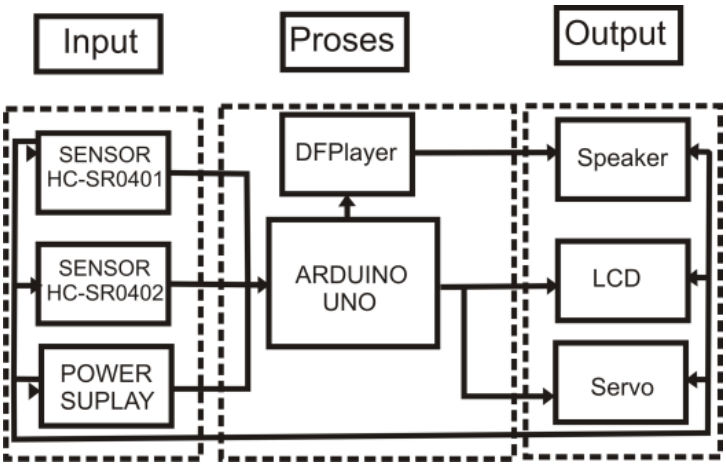
.

2. Method

The research method utilized software design, hardware design, and data collection.

a. Software Design

Software design is made through three stages: input, process, and output, as shown in **Figure 1**.



Picture 1. Diagram block green box.

As seen in **Figure 1,** the process goes through three stages: input, process, and output. The input consists of the HC-SR04 01 sensor as a green box volume meter, and HC-SR04 02 is used as an object distance meter to open the trash can. The power supply is for every tool, such as the HC-SR04 sensor, Arduino Uno, Speaker, LCD, and Servo. Next, Arduino is a data processor given from input and as a sender of processed data results to output. The results of processing the output process through the Speaker convey information on the trash volume in the green box. The LCDs are the volume of the contents of the trash in the trash basket. Servo is used to open and close the trash basket.

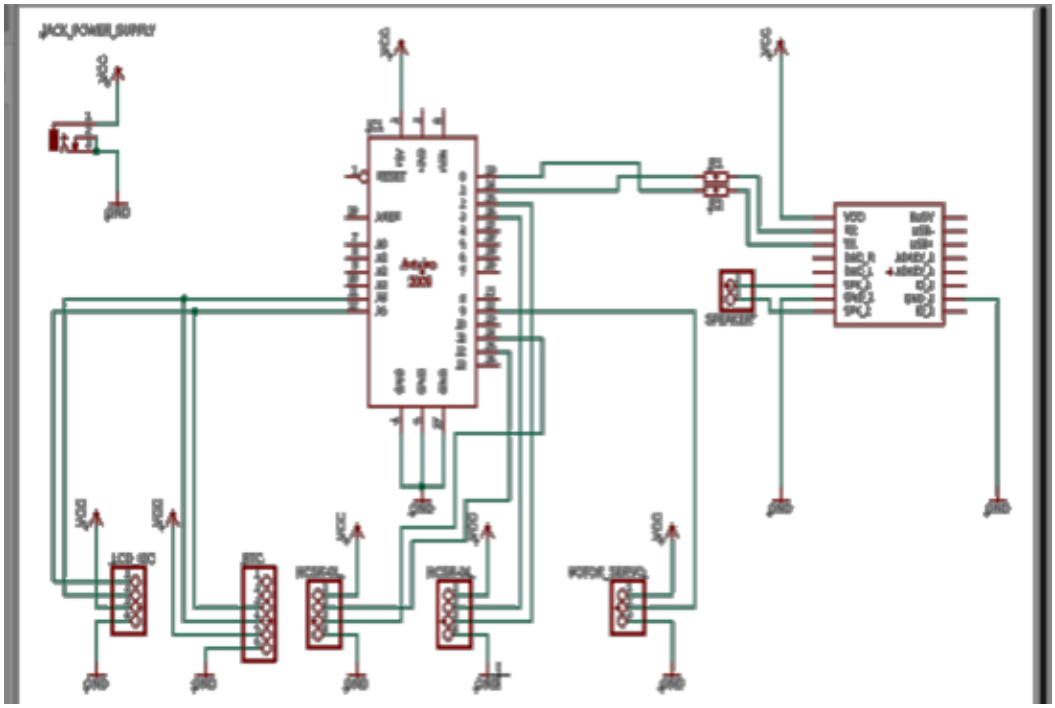


Figure 2. Overall Circuit.

Seen in **Figure 2** are the circuit components used for research. The components used are 2 HC-Sr04 sensors, servo, LCD, Power Supply, and DFplayer.

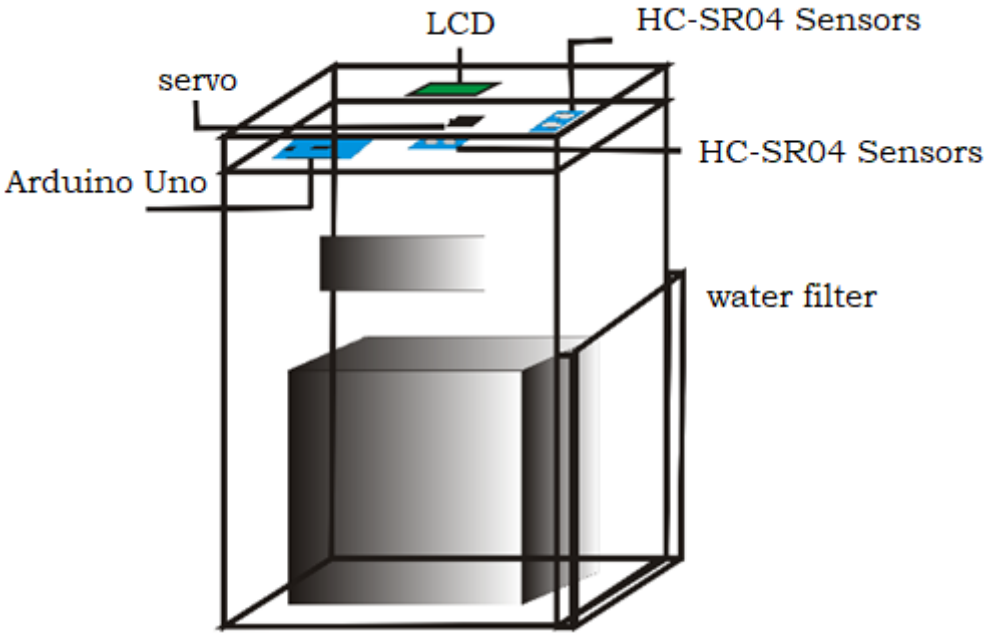


Figure 3. Prototype design.

Seen in **Figure 3** is a prototype of the research conducted. When we want to dispose of Trash, place our hand near the HC-Sr04 1 sensor to move the open trash basket servo. When the trash is placed in the basket, the HC-Sr04 2 sensor measures its volume to display it as a percentage on the LCD. The measurement results are also output through the speakers, whose input is obtained from the DFP layer.

3. Results and Discussion

a. Realization Tool

(a) (b)

Figure 4. Laboratory room prototype, (a) front view, (b) side view

Figure 4. (a) It can be seen from the front that there is a place for opening and closing Trash using a servo drive. The servo moves when an object is brought closer to the ultrasonic sensor 02 with a distance of less than 10 cm. **Figure (b)** Is the side where the janitor collects the trash. Trash disposal is made of an iron plate of 50 × 48 × 100 cm. The inside of the green box is a 48 × 46 × 70 cm box. The trash green box consists of Arduino uno, ultrasonic sensor, LCD, DFPlayer, and Servo.

b. HC-Sr04 Sensor Calibration

Ultrasonic sensors work on the principle of sound wave reflection and are used to detect the presence of a specific object in front of it. The ultrasonic sensor is a sensor that uses ultrasonic waves with a frequency of 20 KHz to 2 MHz. The ultrasonic sensor consists of a series of ultrasonic transmitters called transmitters and ultrasonic receiver circuits called receivers (Sukmawati et al., 2020).

The HC-SR04 senor calibration uses a ruler with a length of 1 meter and a barrier in the form of a book. Calibration is performed from 5 (cm) to 70 (cm). **Equation 1** is used to calculate the sensor distance.

$$d = c \times t_T \tag{1}$$

with d as the distance (m), c as the air velocity (m/s), t_T as time *(s)* (Indrayana et al., 2017).

Equation 1 is used to calculate the distance used by the ultrasonic sensor.

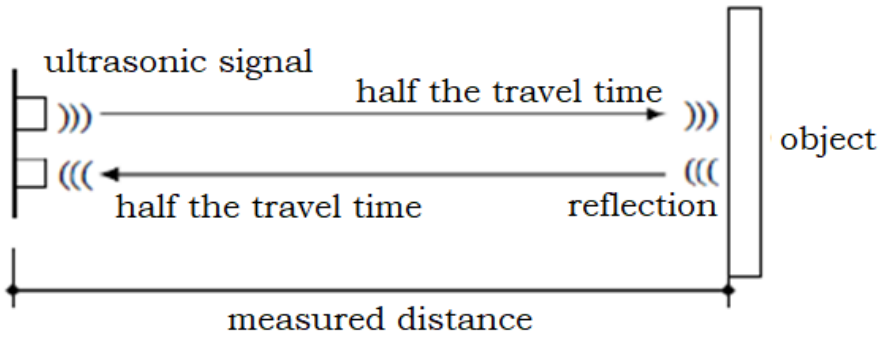


Figure 7. How ultrasonic sensors work.

The ultrasonic sensor consists of two parts: a series of ultrasonic wave transmitters (transmitters) and ultrasonic wave receiver circuits (receiver*)*. It is known that the ultrasonic sensor has a speed of 340 *m/s*. If it travels a distance of 1 *cm* = 0.01 *m* for one way, the time required is 0.01/340 or 0.000029.4 *s* or 29.4 *μs* because the travel time is 2× then to cover a distance of 1 cm 29.4 *μs* × 2 = 58.8 *μs*. The following table shows the time required for the sensor from a distance of 5 cm-70 cm. The following table shows the time it takes for the sensor to emit and receive ultrasonic waves. Based on HC-SR04 sensor testing that has been done, some data is obtained in **Table 1**.

Table 1. First HC-SR04 Sensor Calibration

Test Average	Original distance(cm)	Error Value (%)
70.33	70	0.47
65.16	65	0.25
60.16	60	0.27
55.16	55	0.30
50	50	0
45	45	0
40	40	0
35	35	0
30	30	0
25	25	0
20	20	0
15	15	0
10	10	0
5	5	0
	total error	1.29
	Average error	0.09
	accuracy	0.9991

The results of the calibration are error values at a distance of 55 (cm), 60 (cm), 65 (cm), and 70 (cm) with error values in percent of 0.30%, 0.25%, 0.27%, and 0.47% at 55 cm-70 cm measurement from **Table 1** the total error is 1.29% with an average error of 0.09% and an accuracy of 0.9991%. **Table 1** is formed in a graph seen in **Figure 5.**

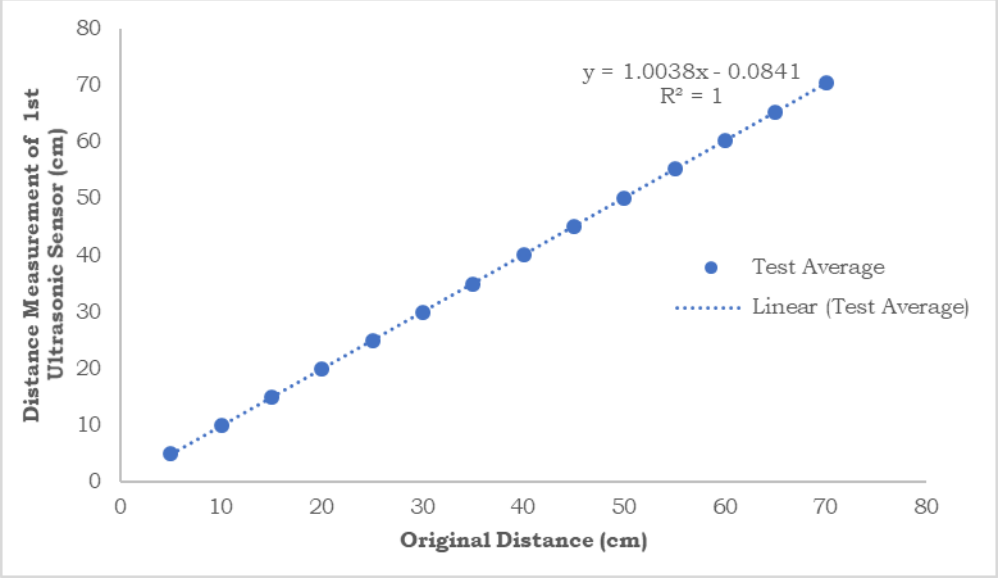


Figure 5. Sensor Calibration Graph 1 HC-SR04

As seen in **Figure 5**, the calibration results obtained as a first sensor graph obtained the value $R^2 = 0.9991$. The average error value of ultrasonic sensor 1 is 0.09%, with the first sensor accuracy of 0.9991%. The results are said to be very good.

Table 2. Second HC-SR04 Sensor Calibration

Test Average	Original distance(cm)	Error Value%
70.33	70	0.47
65	65	0
60	60	0
55	55	0
50	50	0
45	45	0
40	40	0
35	35	0
30	30	0
25	25	0
20	20	0
15	15	0
10	10	0
5	5	0
total error		0.47
Error average		0.03
accuracy		0.9997

As seen in **Table 2,** the results of the second sensor calibration have an error value at a distance of 70 (cm) with an error value in percent of 0.47% of **Table 2**. The total error is 0.47%, with an average error of 0.03% and an accuracy of 0.9997%. **Table 2** is formed in a graph shown **in Figure 6.**

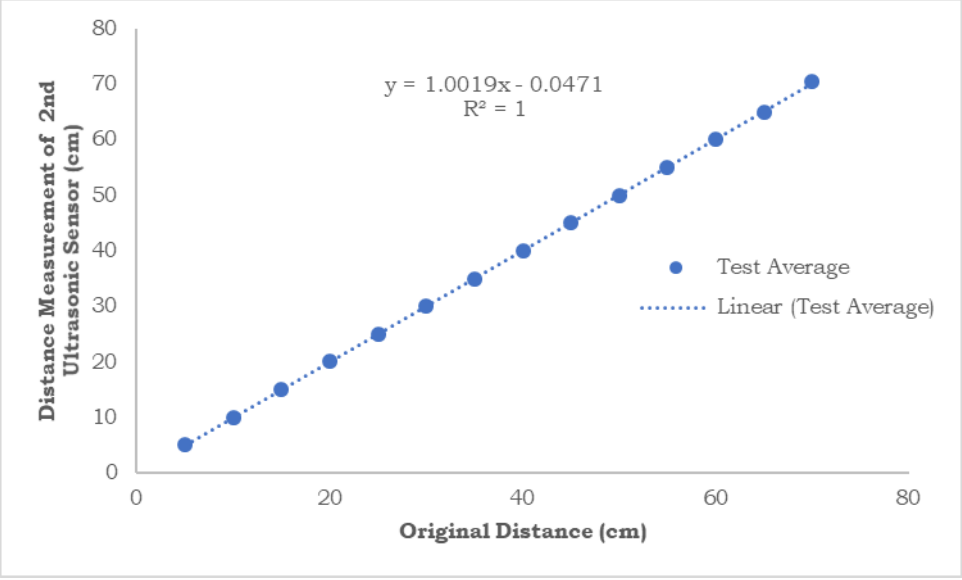


Figure 6. Sensor Calibration Graph 2 HC-SR04

As seen in **Figure 6,** the calibration results obtained from the second sensor graphs obtained the value of R^2 = 0.9997. The average error value of ultrasonic sensor 2 is 0.03%, with a second sensor accuracy of 0.9997%, and the results are promising.

c. Measure the Travel Time of the HC-SR04 Sensor

This sensor test aims to determine the feasibility of the HC-SR04 sensor to work correctly at a certain distance. Data from the HC-SR04 sensor test results for distance can be seen in **Table 3**.

Table 3. Travel Time for 1st Sensor to Travel a Distance of 5-70 cm

No	Travel time h sensor (µs)						Average t (µs)
	Distance (cm)	Test1	Test2	Test3	Test4	Test5	
1	70	41.16	41.16	41.16	41.74	41.74	41.392
2	65	38.22	38.22	38.22	38.22	38.8	38.336
3	60	35.28	35.28	35.28	35.28	35.86	35.396
4	55	32.34	32.34	32.34	32.34	32.928	32.4576
5	50	29.4	29.4	29.4	29.4	29.4	29.4
6	45	26.46	26.46	26.46	26.46	26.46	26.46
7	40	23.52	23.52	23.52	23.52	23.52	23.52
8	35	20.58	20.58	20.58	20.58	20.58	20.58
9	30	17.64	17.64	17.64	17.64	17.64	17.64
10	25	14.7	14.7	14.7	14.7	14.7	14.7
11	20	11.76	11.76	11.76	11.76	11.76	11.76
12	15	8.82	8.82	8.82	8.82	8.82	8.82
13	10	5.88	5.88	5.88	5.88	5.88	5.88
14	5	2.94	2.94	2.94	2.94	2.94	2.94
			Total travel time of sensor t				309.2816
			The average travel time of the sensor t				22.09154286

From the **Table 3**, the results show that the average time taken by the ultrasonic sensor is ± 22.09154286 µs with a total travel time of ± 309.2816 µs. The closer the distance, the faster the time taken by the sensor to send a signal and receive a signal.

Table 4. Travel Time for 2nd Sensor to Travel a Distance of 5-70 cm

NO	Sensor travel time (µs)						Average t (µs)
	Distance (cm)	Test1	Test2	Test3	Test4	Test5	
1	70	41.16	41.16	41.16	41.74	41.74	41.392
2	65	38.22	38.22	38.22	38.22	38.22	38.22
3	60	35.28	35.28	35.28	35.28	35.28	35.28
4	55	32.34	32.34	32.34	32.34	32.34	32.34
5	50	29.4	29.4	29.4	29.4	29.4	29.4
6	45	26.46	26.46	26.46	26.46	26.46	26.46
7	40	23.52	23.52	23.52	23.52	23.52	23.52
8	35	20.58	20.58	20.58	20.58	20.58	20.58
9	30	17.64	17.64	17.64	17.64	17.64	17.64
10	25	14.7	14.7	14.7	14.7	14.7	14.7
11	20	11.76	11.76	11.76	11.76	11.76	11.76
12	15	8.82	8.82	8.82	8.82	8.82	8.82
13	10	5.88	5.88	5.88	5.88	5.88	5.88
14	5	2.94	2.94	2.94	2.94	2.94	2.94
			Total travel time t				308.932
			The average travel time t				22.06657143

Table 4 shows that the average time spent on the ultrasonic sensor is 22.06657143 µs with a total travel time of 308.932 µs. The closer the distance, the faster the time taken by the sensor to send a signal and receive a signal.

d. Tool Test

After calibration, the tool is tested on the green box of Trash. The results of testing the green box volume of trash can be seen in **Table 5**.

Table 5. Green Box Test

No	Green Box test					
	LCD	Sensors 1	Sensors 2	DFPlayer	RTC	Servos
1	YES	YES	YES	YES	YES	YES
2	YES	YES	YES	YES	YES	YES
3	YES	YES	YES	YES	YES	YES
4	YES	YES	YES	YES	YES	YES
5	YES	YES	YES	YES	YES	YES

The tool test was carried out five times for each device used. On the LCD test, the LCDs the trash volume and hours so that we can see directly the capacity. The LCD is under what is programmed, so it can be said that the LCD is functioning according to the program made (**Figure 7**).

Figure 7. LCD

Sensor testing 1 with the method bringing a closer hand to the ultrasonic sensor with a distance of less than 10 cm sensor will Work with moving servo *output.* Testing is done as much as five times from the resulting test. The sensor is working according to the program that has been made seen in **Figure 8**.

Figure 8. Test green sensor box 1

The 2nd HC-SR04 sensor test was performed five times by filling the trash in the green box. After putting it in the trash, the output from the second sensor was displayed on the LCD, which stated the trash volume in percent during the test; the volume change was obtained when the Trash was put into the green box according to the program that has been made shown in **Figure 9**.

Figure 9. Green box sensor test 2

DFPlayer on the green box is used as information storage in mp3 form. Dfplayer provides information every 10 minutes. The mp3 data stored is in the form of a unit number where the result of the unit number will be converted to a percentage value on the LCD, apart from the DFPlayer output LCD through the speaker. DFPlayer testing was carried out five times. DFPlayer works based on numeric codes, so the Arduino Uno program is processed in numbers 001 to 0034 on the sd card. The numbers represent the types of words that the speakers will issue. Program snippet made on Arduino.

```
}
void puluhan(int angka) {
  int tmp1, tmp2;
  tmp1 = angka / 10;
  tmp2 = angka % 10;

  switch (tmp1) {
    case 1: {
        if (tmp2 == 0)        mp3_play (10);//
        else if (tmp2 == 1)   mp3_play (11);
        else if (tmp2 == 2)   mp3_play (12);
        else if (tmp2 == 3)   mp3_play (13);
        else if (tmp2 == 4)   mp3_play (14);
        else if (tmp2 == 5)   mp3_play (15);
        else if (tmp2 == 6)   mp3_play (16);
        else if (tmp2 == 7)   mp3_play (17);
        else if (tmp2 == 8)   mp3_play (18);
        else if (tmp2 == 9)   mp3_play (19);
        break;
      }
    case 2: mp3_play (2); delay(1000); mp3_play (26); break; // 26 file "puluh"
    case 3: mp3_play (3); delay(1000); mp3_play (26);break;
    case 4: mp3_play (4); delay(1000); mp3_play (26);break;
    case 5: mp3_play (5); delay(1000); mp3_play (26);break;
    case 6: mp3_play (6); delay(1000); mp3_play (26);break;
    case 7: mp3_play (7); delay(1000); mp3_play (26);break;
    case 8: mp3_play (8); delay(1000); mp3_play (26);break;
    case 9: mp3_play (9); delay(1000); mp3_play (26);break;
    case 10: mp3_play (34);  break;
```

Figure 10. DFPlayer program

As seen in **Figure 10** command program to DFPlayer to play the desired mp3. *int* tmp1, tmp2 mentions DFPlayer to encode ones and tens digits. int is an integer, so decimal digits are ignored. The tmp1=number/10 and tmp2=number%10 programs make units and tens numbers where decimal digits can be used. *Switch* tempt 1 is a command if it has a value of more than 10, then *case* 1 rotates the tens digit, case 2 to case 9 is a program made to command the addition of words so that the numbers will be read twenty, twenty-one, and so on.

4. Conclusions

A digital instrumentation system for Arduino Uno-based trash bins was successfully made with the devices used, namely Arduino Uno, HC-Sr04 sensor, servo, LCD, and DFPlayer. Ultrasonic sensors in the Trash Green Box system work well by measuring volume and can detect when an object is approaching with a distance of less than 10 cm. The assembly of the green box using the HC-SR04 sensor, which is integrated with Arduino Uno, functions according to the program made. If in the green box, there is HC-Sr04 1 sensor trash, it will measure the volume of trash and then display it via the LCD, and if an object approaches the HC-Sr04 sensor 2, then the servo moves so that the green trash box can open.

5. Bibliography

Amurwahaja, I. P. (2003). *Analisis Teknologi Pengolahan Sampah dengan Proses Hirarki Analitik dan Metoda Valuasi Kontingensi (Studi Kasus Di Jakarta Timur).* Thesis. Institut Pertanian Bogor.

Chairul, M., Tanaka, M., & Shekdar, A. V. (2007). Municipal solid trash management in Indonesia: Status and action strategy. *Journal of the Faculty of Environmental Science and Technology, Okayama University.* 12(1):41-49.

Kardono. (2007). Integrated solid trash management in Indonesia. *Proceedings of the International Symposium on EcoTopia Science.* 629–633.

Syaifudin, M., Rofii, F., & Qustoniah, A. (2019). Rancang Bangun Sistem Monitoring Tempat Sampah Rumah Tangga dan Penerangan Jalan Berbasis Wireles Sensor Network (WSN). *Transmisi: Jurnal Ilmiah Teknik Elektro*, 20(4), 158-166. https://doi.org/10.14710/transmisi.20.4.158-166

Sukarjadi, Arifiyanto, Setiawan, D. T, & Hatta, M. (2018). Perancangan dan Pembuatan Smart Trash Bin di Universitas Maarif Hasyim Latif. *Teknika : Engineering and Sains Journal.* 1(2): 101-110.

Sukmawati, N., Sawitri, A., & M. Rizki G. N. (2020). Rancang Bangun Seleksi Kendaraan Sederhana menggunakan Sensor HC-SR04. *SAINTIFIK*, 6(1), 49-56. https://doi.org/10.31605/saintifik.v6i1.248

Indrayana, I. P. T., Juliana, T., & Triyana, K. (2017). Pengujian Akuisisi Data Sensor Ultrasonik HC-SR04 dengan Mikrokontroler Atmega 8535. *Uniera.* 6 (1): 35-40).