Design of function generator using arduino due 12 bit dac

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Abstract. Most function generators are composed of analog components, which make the function generator have relatively large dimensions. With relatively large dimensions of the tool, making the tool is not easy to carry everywhere. To make the dimensions of the tool become easier to bring everywhere, the waves generated by the function generator are not made from analog circuits, but are made from digital data stored on the microcontroller and then converted to analog with DAC pins. The method of this research is experimental method. The first thing began with a literature study of the components needed and then continues with the making of system design to generate smaller function generator which can display 4 waves, waves that can be displayed are sine waves, squares, triangles, and sawtooths. The results of the study showed that the function generator was successfully made with smaller dimensions with 10 x 15 cm so that it was easier to carry everywhere and was able to produce sine, square, triangle and sawtooth waves with Vpp of 2.24 volts, Vmax of 2.72 volts, and frequency of 1 KHz.

1. Introduction
Function Generator is an electronic device that can produce or generate waves with various forms, such as sine, square, triangle and saw signals [1]. Any electronic measurements laboratory needs signal generators capable to generate several types of signals with different shapes, frequencies and amplitudes [2]. In a previous study conducted by Montree Siripruchyanunin showed that a function generator could be made, but in that study only produced a square wave [3]. And there are still many function generators composed of analog components as wave generators. This causes the tool to have a relatively large dimensional shape and difficult to carry anywhere [4].

With the development of the era of microcontroller technology, more IC product developers can offer microcontrollers with DAC systems that are included. In carrying out its role, DAC plays an important role in performing processing signals [5]. DAC stands for Digital to Analog Converter. DAC has a function as a transformer of digital data into analog data capable of being used to create function generators. In this study, the DAC used was 12-bit DAC because it has high-speed accuracy and operates up to 600 MS / s and gives differential output from 0.5 volts to 50 omega loads [6]. With that, the function generator can have smaller and easier dimensions taken everywhere.

This research use Arduino DUE as microcontroller. Arduino DUE is the first Arduino board to use the arm core as a microcontroller. Equipped with 54 pins of digital input and output and 12 analog input pins. DUE has 2 pins with a 12 bit DAC system in it [7]. The higher bit value offered by the microcontroller indicates that the better waves can be produced. This research use LCD 16x2 for interface. LCD (Liquid Crystal Display) is a component that is used to display or provide certain
indicators on an electronic device to facilitate users in operating it [8]. Other constituent components are potentiometers to change voltage and frequency. Potentiometers are electronic components that have resistance. Potentially structured consists of 3 feet with a lever that can be rotated to determine the value of resistance. Push Button is an electronic component that functions as a breaker or connecting electrical current from the current source to the load, and used for change signal form [9]. The banana socket is a connecting terminal between one conductor and another conductor [10]. TL084 is an IC that has 4 operational amplifiers (op-amp) inside it. The op-amp is a component that has 2 input pins with 1 output pin. The op-amp can be assembled into a wave amplifier circuit [11].

2. Method
The method of this study is the experimental method. The first thing began with a literature study of the components needed and then continues with the making of system design in the form of software and hardware design.

![Diagram block circuit](image)

**Figure 1.** Diagram block circuit

Figure 1 shows a block diagram of the function generator circuit. The power used is powerbank which has a voltage of 5 volts. The Arduino DUE block has 2 functions. The first function is as a digital data storage medium of the wave that will be generated and serves as a digital data converter in the form of analog. The change process produces wave that are compatible with digital data from Arduino. Potensio block functions as a change in the output voltage of the wave produced. Block gain serves to amplifier the wave as desired. The resulting output is then displayed using an oscilloscope.

3. Result and Discuss
The results and discussion in this study are divided into several parts, function generator mode I and mode II, and testing is done as much as the waveforms that can be produced. Mode I is a feature of the function generator that is used to reduce the voltage generated by waves. The voltage drop process utilizes the resistance value of potensio 1. The first test result is a sine wave produced by the function generator. Sine waves with a resistance value of potentio of 0 can be seen in Figure 2.

![Sines Wave](image)

**Figure 2.** Sines Wave
Figure 2 shows that the sine wave has Vpp (Peak to Peak Voltage) or commonly called the peak to peak voltage of 2.24 volts. Sine waves have Vmax or commonly called the peak voltage of 2.72 volts. The resulting wave has a frequency of 1 KHz. The second test result is the square wave generated by the function generator. Square waves with a resistance value of potentio of 0 can be seen in Figure 3.

![Square Wave](image)

**Figure 3. Square Wave**

Figure 9 shows that square waves have Vpp of 2.24 volts, Vmax of 2.72 volts and have a frequency of 1 KHz. The third test result is a triangle wave. A triangle wave with a resistance value of potentio of 0 can be seen in Figure 4.

![Triangle Wave](image)

**Figure 4. Triangle Wave**

Figure 4 shows that the triangle wave has Vpp of 2.24 volts, Vmax is 2.72 volts and has a frequency of 0.9 KHz. The fourth test result is a saw wave. Circular sawtooths with a resistance value of potensio of 0 can be seen in Figure 5.
Figure 5. Sawtooth Wave

Figure 5 shows that the saw wave has a Vpp of 2.24 volts, Vmax of 2.72 volts and has a frequency of 0.9 KHz. After the sine, square, triangle and sawtooth wave data are obtained with a resistance value of a potentiometer of 0 Ω which is capable of producing waves with maximum voltage, the next thing tested is to increase the potensio value to 10 kΩ. The test results can be seen in figure 6.

Figure 6. Wave Forms with 10 k

From the tests that have been conducted, a table of test results can be made. Table of test results can be seen in Table 1.
Table 1. Test result mode I

| No. | Waves     | Vpp (Volt) | $V_{max}$ (Volt) | F (KHz) |
|-----|-----------|------------|------------------|---------|
| 1.  | Sine      | 2.24       | 2.72             | 1       |
| 2.  | Square    | 2.24       | 2.72             | 1       |
| 3.  | Triangle  | 2.24       | 2.72             | 0.9     |
| 4.  | Sawtooth  | 2.24       | 2.72             | 0.9     |
| 5.  | Sine      | 0.12       | 0.04             | -       |
| 6.  | Square    | 0.12       | 0.04             | -       |
| 7.  | Triangle  | 0.12       | 0.04             | -       |
| 8.  | Sawtooth  | 0.12       | 0.04             | -       |

Table 1 shows the sine signal has a Vpp of 2.24 volt and a frequency of 1 KHz which is caused by the maximum voltage of the Arduino output pin. The maximum vpp with a value of 2.24 volt and maximum frequency with a value of 1 KHz are also caused by the obstacles given equal to 0 Ω, or the same as the signal issued does not choose the obstacle so that the sinus signal can issue the maximum voltage and frequency. This also applies to the square signal, triangle and sawtooth which has the maximum voltage and frequency. The sine signal which is given a maximum resistance with a value of 10K makes the signal has voltage and frequency minimum. This also applies to square signal, triangles, and sawtooths that are given maximum resistance so that it makes output signal the output does not have its original form. Mode II is an additional feature of the function generator. In mode II, there is an amplifier circuit. The amplifier circuit uses 2 potentio to adjust the desired gain. The results of the first test were carried out using sine waves and can be seen in Figure 7.

Figure 7 can be seen that there are 2 waves displayed by an oscilloscope. The yellow wave shows the input wave before amplified. The pink wave shows a wave image that has been amplified. With Vpp displayed input wave of 0.8 volts and Vpp output wave of 1.12 volts. This shows 2 potentio arranged in
such a way as to produce a gain of 1.4x. The results of the second test are carried out using square waves and the test results can be seen in Figure 8.

![Figure 8. Square Wave’s Input and Output](image)

Figure 8 shows the yellow wave is an input wave before amplified. Pink waves are waves that have been amplified. With Vpp input waves is 0.84 volts and Vpp output wave is 1.16 volts. This shows 2 potentio arranged in such a way as to produce a gain of 1.38x. The next test is carried out using a triangle wave. The test results can be seen in Figure 9.

![Figure 9. Triangle Wave’s Input dan Output](image)

Figure 15 shows the results of a triangle wave which an oscilloscope displays. The yellow wave shows the input wave set with potensio 1 and the pink wave is the output wave that has been amplified by setting the potentio 2. The Vpp input wave is 0.8 volts, and the Vpp output has been amplified by 1.08
volts. This shows the potential 1 setting and potential 2 has a gain of 1.35x. The last test was carried out using a saw wave. The test results can be seen in Figure 10.

![Sawtooth Wave's Input dan Output](image)

**Figure 10.** Sawtooth Wave’s Input dan Output

Figure 16 shows the results of a sawtooth wave test with a yellow input wave and a boosted output wave that is pink. With Vpp input wave is 0.76 volts and the Vpp output wave has been amplified at 1.08 volts. This shows potential 1 and potential 2 are arranged in such a way as to produce a gain of 1.4x. From the test results from mode II, a test result table can be made which can be seen in Table 2 with the following reinforcement calculations:

\[
\text{Gain} = \frac{\text{Vpp Output}}{\text{Vpp Input}} \quad (1)
\]

| No. | Waves | Vpp Input | Vpp Output | Gain  |
|-----|-------|-----------|------------|-------|
| 1.  | Sine  | 0.8 volt  | 1.12 volt  | 1.4 x |
| 2.  | Square| 0.84 volt | 1.16 volt  | 1.38 x|
| 3.  | Triangle| 0.8 volt | 1.08 volt  | 1.25 x|
| 4.  | Sawtooth| 0.76 volt | 1.08 volt  | 1.4 x |

The results of the function generator design can be seen in Figure 11, and the tool dimension shown in figure 12.
Figure 11 shown the number of that tool. The description are:

1. Output produced from the Arduino DUE DAC pin
2. Ground
3. LCD
4. Switch to select Mode I or II
5. Output that can be changed based on no 7. with a max output voltage of 1.5 volts
6. Ground
7. Output setting ratio no 5. on mode I and input setting ratio no 5. on mode II
8. Push button to select the form of the signal being issued
9. Ratio of output setting No. 10 to mode II
10. Output that can be changed based on no. 9.
11. Ground

Figure 11. Function Generator 12 Bit DAC

Figure 12. Tool Dimension
4. Conclusion
From the research that has been done, it can be concluded that the Arduino DUE-based 12-bit DAC Generator Function has been successfully created by producing 4 different waveforms, namely sine, square, triangle and sawtooth wave with potential as output voltage control in the function generator mode I. Function generator is able to use amplification in II mode with 1.4x gain without changing the shape of the signal. And function generators have dimensions 10 x 15 cm that are easy to carry everywhere.

5. References

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