PRODUCT DESIGN OF PORTABLE OSCILLOSCOPE USING ARDUINO TO ANALYZE SIGNAL

Wildan Maulana[1], Nyoman Bogi Aditya Karna[2], Ridha Muldina Negara[3]

[1,2,3]Telecommunication Engineering Department, School of Electrical Engineering, Telkom University
[1]**wildaanm@student.telkomuniversity.ac.id**, [2]**aditya@telkomuniversity.ac.id**,
[3]**ridhanegara@telkomuniversity.ac.id.**

Abstract

An electrical signal is an electrical voltage or current that carries information. The term electrical signal in a circuit can refer to voltage or current. Voltage or often people call with potential differences, is the energy carried out to move a single charge, while an electric current is a change in the speed of a charge with respect to time or charge that flows in units of time. In a research or scientific project, measurement tools are often needed that can project the form of electrical signals to be seen and studied. One measuring instrument commonly used is the oscilloscope (oscilloscope). Oscilloscopes are usually used to observe the exact wave shape of an electrical signal. This measuring instrument works based on data samples, the higher the data sample, the more accurate the electronic equipment. Oscilloscopes usually have very high data samples, so Oscilloscopes are very expensive electronic measuring devices. If an oscilloscope has a sample rate of 10 Ks / s (10 kilos of sample / second = 10,000 data per second), then this tool will read 10,000 times a second. However, not all scientific research or projects require a type of Oscilloscope that has such a high level of accuracy, there are some of them needed just to learn a basic introduction to electrical signals, there are several other cases needed to be practically portable, so it is easy to use at the time is required. But in the market today, Oscilloscope products are dominated by products of manufacturing manufacturers with large and heavy dimensions, of course with relatively very expensive costs and generally for the needs of laboratory procurement.

Keywords: Oscilloscope, Electrical Signal, Portable, Electronic Measuring Instruments.

1. Introduction

Electrical signal (electrical Signal) is a voltage or electric current that carries information. The term electrical signal in a circuit can refer to voltage and electric current. Voltage or often people refer to a potential difference, is the energy that is done to drive a single charge, while the electric current is a change of payload speed to the time or load flowing in the time unit. In other words the current is a moving charge. As long as the charge is moving it will appear current but when the charge is silent then the current will be lost.

The common types of electrical signals in the know are AC and DC (Alternating Current and Direct Current) the term AC (alternating) and DC (unidirectional) are not absolutely embedded in the flow alone. However can and usually also intended at voltage sources e.g. 220V AC or 12v DC, both types of electrical signal is a very important waveform in the field of electronics, where the waveform that formed in 1 second is called as the Frequency measured in Hertz (HZ) units. Both of these electrical signals are common examples used in research or scientific projects, especially for researchers, students and students in the fields of electronics and derivatives.

In a study or scientific project it is often necessary measuring instruments that can project the form of electrical signals in order to be seen and studied. One of the commonly used measuring instruments is Oscilloscope. Oscilloscope is typically used to observe proper waveforms of the electrical signal. The measuring instrument works based on the sample data, the higher the data sample, the more accurate the electronic equipment is. Usually the Oscilloscope has a very high sample of data, therefore the Oscilloscope is a very expensive electronic measuring instrument. If an oscilloscope has a sample rate of 10 Ks/s (10 kilos sample/second = 10,000 data per second), then this tool will perform the reading as much as 10,000 times in a second.

2. Basic Concept

2.1 Oscilloscope

The oscilloscope is an electronic measuring instrument that functions to project the electrical signal form to be seen and studied. Initially the oscilloscope consisted of a cathode ray tube and an electron transmitter device that functioned to project the electron beam to the cathode screen, so that the electron beam was used on the screen and with the help of some special circuits Inside the oscilloscope will cause the spotlight to move repeatedly from left to right of the screen [4]. The highlight repetition is the one that causes the continuous signal form on the screen so that the signal can be seen and learned. Today there are two (two) types of oscilloscope, the analog oscilloscope and the digital oscilloscope. Each type of oscilloscope has its advantages and limitations.

1. Analog Oscilloscope

The analog oscilloscope works by describing the electrical waveforms through the electron beam in a cathode ray tube that runs from left to right. The beam of electrons emitted by the electron gun section will hit the wall of the cathode screen so that the electrons in the phosphorus layer of the screen will excitation and result in a

luminescence or flame on the screen, which will be the Draw the base of the waveform measured by the oscilloscope [4]. In the analog oscilloscope, the waveform that will be displayed on the screen is arranged by a pair of deflector plates vertically or horizontally, the layer of the electron beam is performed by the coating where the The deflow is given a certain voltage it will result in the beam of electrons to turn at a certain price anyway. For example, if the voltage on all of the plates is 0 (zero) Volt, then the beam of electrons will move straight to the screen so that the screen will only appear a flash point in the middle of the screen. The tension adjustment layer will be related to the Time/DIV setting for the horizontal Defter layer, and corresponds to the Volt/DIV setting for the vertical-defter layer.

2. Digital Oscilloscope:

   If on the wave analog oscilloscope displayed on the screen is directly given from a series of vertical electron emission disconnection layer so that it is effective "real time", then the digital oscilloscope of the wave will be displayed first through Sampling stage and then the data of the sampling result is processed digitally. The digital oscilloscope stores the sampled voltage values along with its rolling timescale on temporary memory before it is displayed [4]. In principle, the digital oscilloscope works by sampling the signal, storing data, processing data, then displaying the data processing results and then repeating back as such. The digital oscilloscope has 2 (two) ways to depict the input signal, single shot or real time sampling. With both of these techniques, the oscilloscope obtains all the signal footage with one trigger event. Unfortunately a cuplic oscilloscope rate will limit the bandwidth of the oscilloscope when operating in real time (realtime). In theory the digital oscilloscope requires input with at least 2 (two) snippets per signal period (wave) to reconstruct a waveform. However, in practice, 3 (three) or more snapshots of each wave period will provide better acquisition accuracy [6].

2.2 Basic Concept of Signal

Signals are a phisycs of time functions containing information. Signals are usually susceptible to interference and interference from other signals both from within the system and from outside the system. In the world of electronics there are 2 (two) types of signals commonly known, namely analog and digital signals. Both signals have their own characteristics, and in their use they differ from each other, since each signal has advantages and disadvantages in accordance with the transmission media and the type of communication It uses [7].

1. Analog Signal

        Analog signals are data signals in a continuous waveform, which carries the information by altering the wave characterisitics. The two most important parameters/ characteristics that are owned by the analog signal waves are the amplitude and frequency. These analog cues are usually expressed with sine waves, given the sine wave is the basis for all forms of analog cues. Waves on analog signals are generally sine wave-shaped that have 3 (three) basic variables: Amplitude is a high size low voltage of the analog signal, Frequency is the number of analog signal waves in seconds, and phase is a large angle of analogue signal at certain moments.

2. Digital Signal

     Digital signal is a data signal in the form of pulse that can undergo sudden changes and has a price of "0" (Logic Low) and "1" (Logic High). Digital signals have only 2 (two) states, "0" and "1", so they are not easily affected by noise. In general digital signals are also referred to as discrete signals. Since digital signals only have two circumstances, the value of this digital signal is usually called a bit. BITS is a typical term for digital signals. The possible value for a bit is 2 pieces, and the possible values for 2 (two) bits are 4 pieces (00, 01, 10, and 11). In general the amount of possibilities that can be formed from a N bit combination is 2n pieces of fruit. The digital signal system is the result of the sampling of analogue signals. Digital signals are essentially in the code into binary form or into Hexadesimal form. Large value of a digital signal is limited by the bandwidth of the data or the number of bits it uses. The greater the number of bits used then the reading value of the sampling result will be more accurate.

2.3 ADC (Analog to Digital Converter)

   Analog to Digital Converter, also known as ADC, is a series that serves to convert an analog signal into a Digital signal. By using ADC, we can observe Signal changes such as voice signals, radar signals, sonar signals, and various other signals which are analog signals. The most important thing of an ADC series is the resolution, which is the smallest analog that can be converted into digital units. To process analogue signals with a digital device, the first need to convert from analog to digital magnitudes is by converting into a numeric series with limited precision denoted into binary form. This procedure is called an analog-to-digital conversion (A/D Converter). A signal contains information about the amplitude, frequency and phase angles. To get such information from a signal using an analog device is complicated and less accurate. Therefore, it is usually used to process the digital processing method. For the digital signal to be obtained quite accurately to be returned to an analog signal it is worth noting the number of snippets (sampling) by the ADC device and the magnitude of the numbers used to represent each of the footage

2.4 Sampling

When the switch closes briefly then re-open   ed then the C capacitor will be charged the same large load with the big signal X (t) when the switch is closed. The buffer circuit is assigned to allow the payload on the capacitor to stay awake while being used by the next process. The sampling speed of the signals from the analogue signals to be converted must meet the Nyquist criteria. Where the minimum sampling frequency (Fs) is 2 (two) times the frequency of the maximum analog signal to be converted (Finmax). For example if the analog signal to be converted has a frequency of 100 Hz then the sampling frequency of the ADC is at least 200 Hz. Or when reversed, if the frequency sampling ADC amounted to 200 Hz then the analog signal to be converted must have The maximum frequency of 100 Hz. When this Nyquist criterion is not met it will arise an effect called aliasing because a certain frequency is seen as another frequency.

2.5 Product Design

Product design is a management tool to translate the results of research and development activities done before being a real ranging that will be produced and sold by generating profit. One of the most important management functions in all organizations is to ensure that input – the input of various organizational resources to produce the precisely designed products or services or produce outputs – outputs that can satisfy Customers wishes. To produce the appropriate output and according to the wishes of the customer, there needs to be product design. Based on some understanding of the product design above, it turns out that the design products have the intention and purpose to help the company in creating and developing new products or to guarantee the results of the Producti to the wishes Customers [8]. The intent of Product Design itself, as follows :
•   To avoid failures – failures that may occur in the manufacture of a product.
•   To select the best and economical method of product manufacture.
•   To determine the standardization or specifications of the product made.
The purpose of Product Design itself is to make the product as efficient as possible in the use of raw materials and costs – costs without prejudice to the selling value of the product.

2.6 Arduino

Arduino is an open-source, flexible, and easy-to-use electronic prototyping system that is both hardware/hardware and software/software-based. Beyond that, the main strength of the Arduino is the number of users who are very much so that there is a library of code libraries as well as supporting modules (Hardware support modules) in a very number. This makes it easy for beginners to get to know the microcontroller world. The Arduino is defined as an open source electronic platform, based on software and hardware that is flexible and easy to use, aimed at artists, designers, hobbies and anyone interested in making an object or An interactive environment [10]. Arduino as a physical computing platform that is open source on a simple input board, which means a physical computing platform here is an interactive physical system with the use of software and hardware That can detect and respond to situations and conditions.

3. Work System

3.1 Product Description

Currently the Oscilloscope products in the market are more specifically aimed at research in the laboratory, which has high accuracy with high sample rate, large and heavy dimensions, not compact, impractical, not easy to carry, is a manufacturing product that already has its own standard according to each manufacturer, so it is difficult to develop and built for other needs and most of all is a very expensive price. If used for research or scientific projects that do not require high accuracy, or for example for basic learning of signals/waves, then the products on the market, including into waste, because of the expensive price, besides Need a certain configuration according to the manufacturer standards, so to operate it need supporting knowledge first.

In this research, the Oscilloscope product design will be simpler, in a portable form, so that it is practically easy to carry, with compact dimensions, easy to build and develop at a cheap cost and can be used and Widely utilized product design in this research will use the Arduino technology, which has been widely known in the development of software products and integrated hardware that can be developed easily, practical and appropriate. It can be distributed more succinctly, as it does not require a space (casing) that takes up spaces, as it is not manufacturated by large machinery/manufacturing. The Oscilloscope products in this study will be made in portable form, specifically used to measure electrical signals.

3.2. Hardware Design

The list of components to be used in the design of the Oscilloscope product in portable form in this research is as follows:
   ☐   1 piece of Arduino MEGA Board
   ☐   1 piece of LCD TFT 2.4 Inch

- ☐   2 pieces of Cable Multimeter Tester (Positive/Negative)
- ☐   1 piece 9 Volt Power Suppy
- ☐   1 piece of Potensiometer 10 kilo ohm
- ☐   1 piece of Switch Analog Input

Next is the diagram scheme that will be used in hardware design on the Oscilloscope product design in this study, can be seen in the image below as follows:
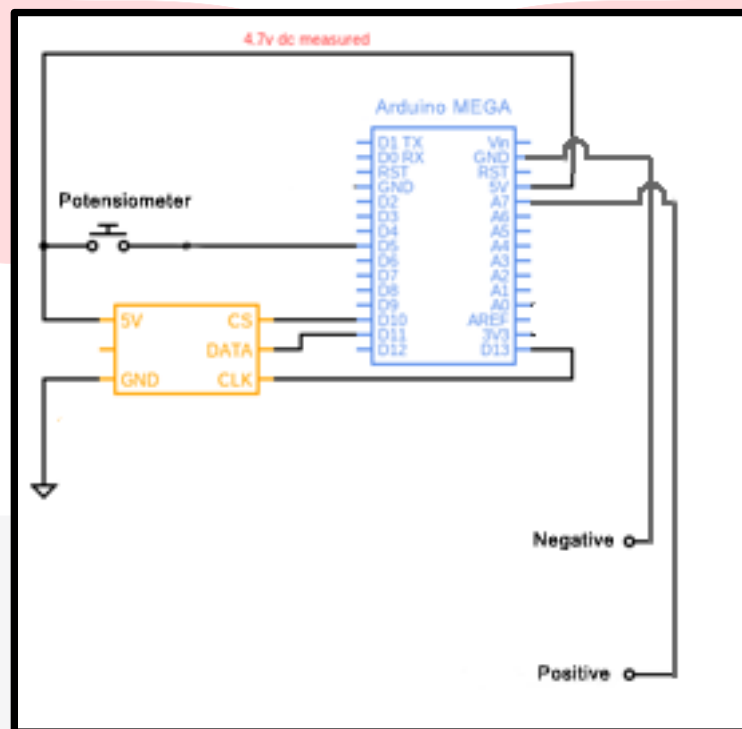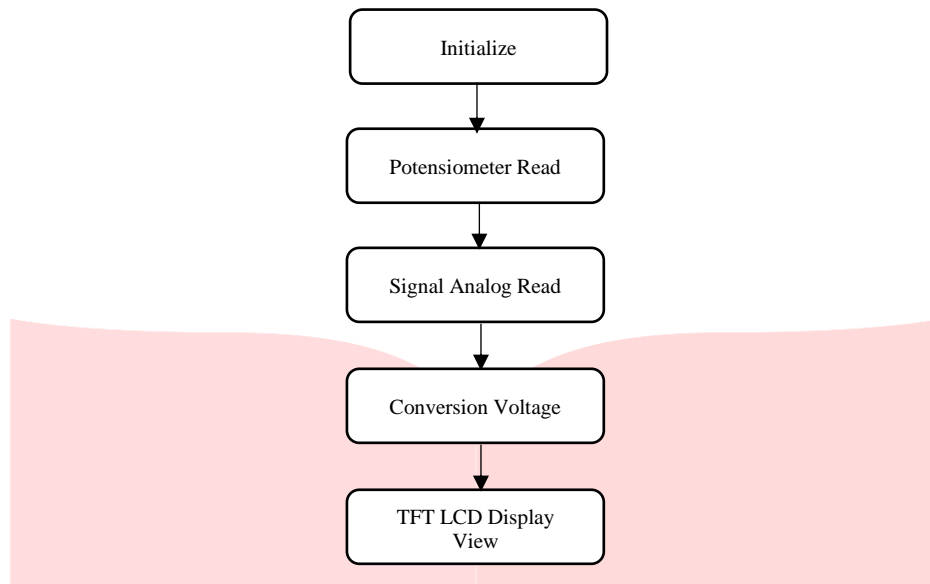

Figure 3.1 Diagram Scheme

Figure 3.1 represents the diagram scheme, Arduino MEGA Board has available an Analog Read feature that will be used to read electrical signals. The electrical signal gained from the Analog readings is converted into volts with a maximum 0 to 5V range, where the maximum Analog reading value is at 1023. As mentioned in the beginning, the purpose of this research is to make the Oscilloscope products in a portable form, using two different multitester voltmeter cables of color (red = positive, black = negative) that act as connectors to conduct electrical signal testing. Then the time visualization of the converted electrical signal waves is set by using potentiometer as per user requirement. This time is specified in seconds, ranging from a range of 1/10 seconds to 1 second for display visualization updates.

The specification of the output input to be used in the Oscilloscope product design is suitable for the need of electrical signal analysis to obtain a graph result indicating the wave of the voltage connected to the cable multitestervoltmeter (positive/negative), using connectors by preparing two different color jumper cables, namely red color that indicates positive voltage (+), and black color indicating a negative voltage (-).

3.3. Software Design

MCUFriend's KBV library is the main core of the code Adafruit TFT Libraries that are altered to function in the 2.4 inch TFT LCD shield with controller. MCUFriend KBV library can be easy to use and generates the graphical output required for this research. The product design is configured to display the electrical signal waves on the 2.4 inch TFT LCD using the library, which is the development of the AdaFruit library. The display used in this study uses a TFT LCD of 2.4 inch, which can display the electrical signal waves generated by the electrical voltage connected to a voltmeter cable multitester which is only able to test the direct voltage or DC with a maximum of 5 volts.

```
┌──────────────────┐
│    Initialize    │
└──────────────────┘
          │
          ▼
┌──────────────────┐
│Potensiometer Read│
└──────────────────┘
          │
          ▼
┌──────────────────┐
│ Signal Analog Read│
└──────────────────┘
          │
          ▼
┌──────────────────┐
│Conversion Voltage│
└──────────────────┘
          │
          ▼
┌──────────────────┐
│ TFT LCD Display  │
│       View       │
└──────────────────┘
```

Figure 3.2 Arduino Program Design

Figure 3.2 is the program design flow using the Arduino software on the oscilloscope product in this study. The initial stage starts from the initialization stage, where at this stage the program initializes the TFT LCD display module connected to the oscilloscope product, then initializes the voltage stabilization, so that when the product takes measurements, the electrical signal can minimize errors that may occur or deviations from the measured value.

The next stage is the reading of the potentiometer module installed via analog pin A8. This potentiometer will be used to adjust the time division (time / div) of the reading and processing of the electrical signal received by the oscilloscope product. The potentiometer will set the time span required for the oscilloscope to read the electrical signal as input, where the value range is in the numbers 0 ms to 1000 ms (or 1 second) with a step division of 10, or it means that in this case the increase in each rotation of the potentiometer means electrical signal measurements will be measured in 100 ms increments. This is also adjusted to the rotation capability which can be adjusted by the potentiometer, which is as much as 10 steps of displacement from the minimum point to the maximum that can be achieved.

Then synchronize with the potentiometer reading on analog pin A8, which is to read the electrical signal input on analog pin A7, where this pin is connected to the positive cable of the electric signal measuring instrument used. The input from the A7 analog pin is an analog value that can be read by the Arduino MEGA device where the value range is from 0 to 1023. Then the analog value is converted into a voltage measurement with a value range in the minimum range of 0 Volt to 5 Volt. This reading is also in line with the synchronization of time (time / div) which has been set through the reading on the potentiometer module. In essence, the greater the maximum rotation of the potentiometer, the slower the reading of the electrical signal obtained through the A7 analog pin will be slower, and vice versa if the smaller the rotation of the potentiometer is set to the minimum, the delay in reading the electrical signal will be faster. This will form a regular pattern of electrical signals that are successfully measured on the oscilloscope which indicates that the product is functioning properly.

All readings that have been successfully converted into voltage (voltage) will be displayed on the TFT LCD Display, the results will be shown in the form of a pattern on the x and y axes, where the x-axis shows the set number of time ranges (time / div), while the axis y is the result of the amount of the electrical signal that has been successfully measured via analog pin A7. This result is the main output of the oscilloscope product which has the role of providing information about the ability of the tool to measure electrical signals, this is the main thing in product design.

3.4. Product Testing
3.4.1 Arduino MEGA Testing
Arduino MEGA testing is done by programming the hardware by making one of the input analog pins into positive and negative values, That is a value of 0 and 1, repeatedly with a delay of 100 ms, then the voltage coming out of the analog pin of the input is measured using a multitester voltmeter. Testing this MEGA Arduino to ensure that the Arduino used in the study is not damaged or malfunctioning. So the sketch program that is installed on the microcontroller is able to function to display the oscilloscope needed to measure the electrical signal in a given time unit. The components used for this MEGA Arduino testing are as follows:
1. Arduino MEGA
2. 9 Volt Power Suppy

3. Multitester Voltmeter
4. Laptop / Notebook
5. Software Arduino IDE
6. USB 2.0 Type A/B Cable
7. Manual Stopwatch

There are several stages that will be carried out in accordance with the test objectives, such as:
1. Connect 9 Volt Power Supply to Arduino MEGA.
2. Then connect the USB 2.0 Type A/B Cable to Arduino MEGA
3. Open Arduino IDE on the Laptop / Notebook
4. Then upload the program to Arduino and activated
5. One of the input analog pins was measured using a multitester of voltmeters, and any outgoing 0 and 1 results were recorded

3.4.2 TFT LCD Testing
The TFT LCD test will be used by the Arduino MEGA as an output to display the oscilloscope graphs according to the output of the analog outputs converted to the size of the electric voltage in Volt units and measured by the adjusted level of accuracy. Testing needs to be done so that it will be reliable over time to provide appropriate display. TFT LCD Testing aims to ensure that the display can run properly and always deliver the correct output results. So that the process of appearance of the oscilloscope graph can be displayed correctly. The components used for TFT LCD testing are as follows:
1. Arduino MEGA
2. 9 Volt Power Suppy
3. Multitester Voltmeter
4. Laptop / Notebook
5. Arduino IDE Software
6. USB 2.0 Type A/B Cable
7. TFT LCD 2.4 Inch

There are several stages that will be carried out in accordance with the test objectives, such as:
1. Connect 9 Volt Power Supply to Arduino MEGA.
2. Then connect USB 2.0 Type A/B Cable to Arduino MEGA
3. Open Arduino IDE on the Laptop / Notebook
4. Upload the program to Arduino and activated

3.4.3 Oscilloscope Testing
Oscilloscope testing is conducted to see the effectiveness of product design to be used to display the oscilloscope graphs used to measure the electrical signal in a given time unit, in portable form that is practical and easy to carry, with compact and lightweight dimensions. The oscilloscope test aims to test whether the product design can be used or not to measure the electrical signal with a adjusted level of accuracy, which is easy to use, easy to make at a relatively inexpensive cost by comparing the results of the analog output obtained from the volume used Multitester cable. The components used for testing the oscilloscope are as follows:
1. Arduino MEGA
2. 9 Volt Power Suppy
3. Laptop / Notebook
4. Arduino IDE Software
5. USB 2.0 Type A/B Cable
6. TFT LCD 2.4 Inch
7. Cable Multimeter Tester (Positive & Negative)

There are several stages that will be carried out in accordance with the test objectives, such as:
1. Connect 9 Volt Power Supply to Arduino MEGA.
2. Then connect USB 2.0 Type A/B Cable to Arduino MEGA
3. Open Arduino IDE on the Laptop / Notebook
4. Upload the program to Arduino and activated
5. In the Arduino IDE application, open the serial monitor facility that will be used to monitor the value of the analog output and the conversion result to the power unit (Volt).
6. Connect Cable Multimeter Tester (Positive & Negative) to the object that can produce electricity (Power source with a 5 volt limit)

3.4.4 Training KIT Module

After we test the Oscilloscope using the multitester cable and the Oscilloscope works well, the next step is to make a simple training KIT to demonstrate and show the Oscilloscope Product works well. IC555 (IC Timer) is an Integrated Circuit that has 8 pins (feet). IC555 is used for various electronic circuits which require a timer and multivibrator function inside. Some circuits requiring IC Timer such as Waveform Generator, Counter, Digital clock, and so on, IC Timer 555 is an IC that produces Oscilation and delay time with high accuracy and stability. Component used for IC555 Circuit are as follows:

1. Oscilloscope
2. 4 pieces of Resistor 1k
3. 1 piece of Capacitor 100uF/25v
4. 2 pieces of LED
5. IC555 Socket
6. 9v Battery

Below is an illustration image of the use of the IC555 Circuit components on a portable oscilloscope which can be seen as follows :
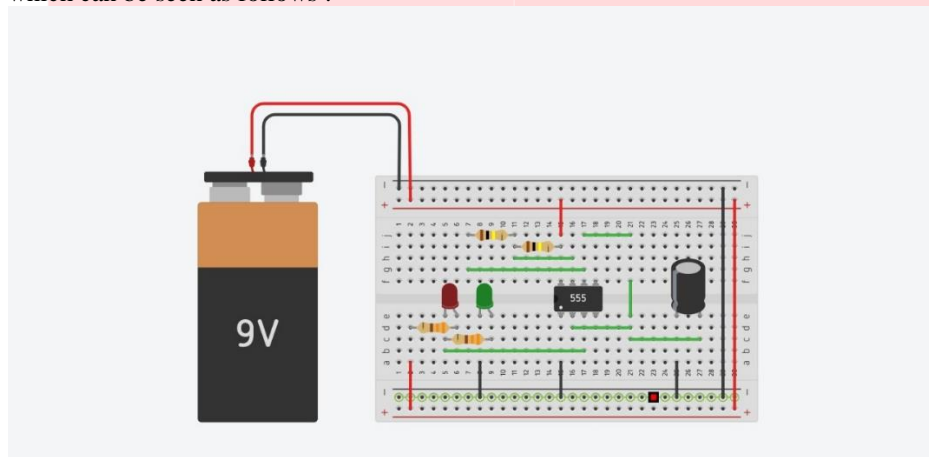
Figure 3.3 IC555 Circuit
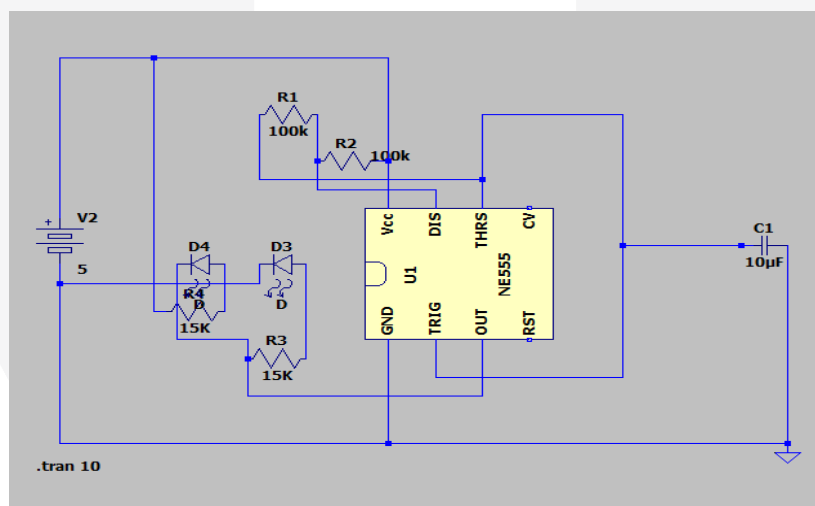
Figure 3.4 IC555 Circuit using LTSpice

3.5. System Testing

3.5.1 Arduino MEGA Testing Result and Analysis

After completing Arduino MEGA testing, as carried out according to the procedure and the list of components used as described in the product design section, then the test results that have been done according to the above testing procedure, are as follows:

Table 3.1 Arduino test results

Time (seconds)	Multitester Voltmeter Output

1	1
2	0
3	1
4	0
5	1
6	0
7	1
8	0

Based on the results of the table 3.2 above, it can be analyzed that the Arduino is functioning properly, because it can provide results with value 1 and 0 in every second of testing, It means that Arduino MEGA can produce positive and negative results.

### 3.5.2 TFT LCD Testing Result and Analysis

After completing TFT LCD Testing testing, as carried out according to the procedure and the list of components used as described in the product design section, then the test results have been done according to the testing procedure above, and TFT LCD can produce the display of the oscilloscope graphs that can be seen in the image as follows:
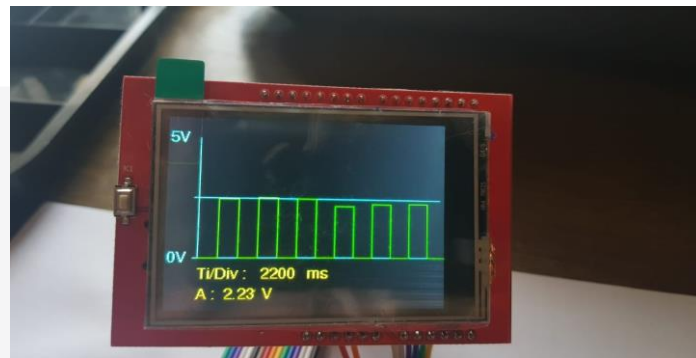
Figure 3.5 TFT LCD Test Results

3.5.3 Oscilloscope Testing

After completing Oscilloscope testing, as carried out according to the procedure and the list of components used as described in the product design section, then below are some of the results captured by the serial monitor facility to get the analog output value, as follows:
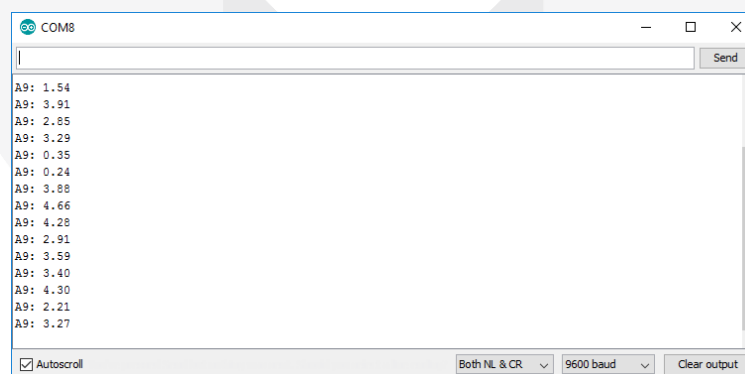
Figure 3.6 Result of Analog Output rate conversion of electric voltage (Volt) from Serial Monitor

From some analog results that have been converted into electrical voltage (Volt) that successfully captured by the serial monitor, the value ranges between 0.0 Volt S/d 5.0 Volt, because the reference voltage value used is 5 volts, the maximum value that can be obtained from this conversion is 5 Volt, because the values obtained are located between 0.0 Volt S/d 5.0 Volt, then it can be considered as MEGA

Arduino and activated programs and sensors have been functioning properly and can be used as an oscilloscope.

This shows that testing of oscilloscope products to measure voltage between 0.0 Volt to 5.0 Volt can be done properly, in accordance with the 5 Volt reference voltage coming from Arduino MEGA. This product can be applied for general electrical measurement needs with a simple tool and a relatively affordable cost

3.5.4 Oscilloscope Sketch Program Analysis

From the sketch program that embedded into the Arduino MEGA via the Arduino IDE application, it is divided into 2 sections, Setup function section and Loop function. These two sections can be seen below as follows:

```
void setup() {
  // put your setup code here, to run once:
    Serial.begin(9600);

    tft.reset();
    uint16_t ID = tft.readID();
    tft.begin(ID);
    tft.setRotation(1);
    //tft.invertDisplay(true);
    tft.fillScreen(BLACK);

    color = CYAN;
    showmsgXY(2,30,1,&FreeSans9pt7b,"5V", CYAN);
    tft.drawFastVLine(35,25,150,color);
    showmsgXY(2,180,1,&FreeSans9pt7b,"0V", CYAN);

    tft.drawFastHLine(30,25,5,color);
    tft.drawFastHLine(30,100,285,color);
    tft.drawFastHLine(30,175,285,color);

    showmsgXY(35,200,1,&FreeSans9pt7b,"Ti/Div : ", YELLOW);
    showmsgXY(35,225,1,&FreeSans9pt7b,"A : ", YELLOW);

    for(int i=0;i<limit;i++)
    {
      voltage[i] = 0.0;
    }

    delay(500);          // wait to get reference voltage stabilized
}
```

Figure 3.7 Sketch Program Oscilloscope Section Setup

```
void loop() {
tft.fillScreen(BLACK);

    showmsgXY(2,30,1,&FreeSans9pt7b,"5V", CYAN);
    tft.drawFastVLine(35,25,150,color);
    showmsgXY(2,180,1,&FreeSans9pt7b,"0V", CYAN);

    showmsgXY(35,200,1,&FreeSans9pt7b,"Ti/Div : ", YELLOW);
    showmsgXY(35,225,1,&FreeSans9pt7b,"A : ", YELLOW);

    int test_up,test_down;
    int time_div;
    char time_str[8];
    char result[8];

    val = analogRead(A8);
    val = round(val/10);

    Serial.println(val);
    time_div = round(100 * val);

    show_line(time_div, BLACK);
    tft.drawFastHLine(30,100,285,color);
    tft.drawFastHLine(30,175,285,color);

    int sensorValue = analogRead(A7);

    // Convert the analog reading (which goes from 0 - 1023) to a voltage
(0 - 5V):
    float signal_v = sensorValue * (5.0 / 1023.0);

    voltage[limit-3] = signal_v;
    voltage[limit-2] = 0;

    Serial.print("Sensor Value: ");
    Serial.println(signal_v);

    dtostrf(time_div, 6, 0, time_str);
    dtostrf(signal_v, 6, 2, result);

    showmsgXY(95,200,1,&FreeSans9pt7b,time_str, YELLOW);
    showmsgXY(158,200,1,&FreeSans9pt7b,"ms", YELLOW);

    showmsgXY(55,225,1,&FreeSans9pt7b,result, YELLOW);
    showmsgXY(108,225,1,&FreeSans9pt7b,"V", YELLOW);

    for(int i=0;i<limit-1;i++)
    {
      voltage[i] = voltage[i+2];
    }

    show_line(time_div, GREEN);
    tft.drawFastVLine(35,25,150,color);

    delay(1000);
}
```

Figure 3.8 Sketch Program Oscilloscope Section Loop

From the sketch program above can be analyzed that the value readings of the electrical voltage (Volt), in the initial reset with all the specified 0 in the limit of 30x readings with certain time units according to the level of adjusted accuracy, after the analog configuration settings and the conversion of the electrical voltage, then do reset the display of TFT LCD with reading the LCD TFT ID first, in order to be activated. In this section of the setup, the TFT LCD display will be set to a black background. Then after the second stage is done, the next process waits until the reference voltage 5 Volt is used, has been stable and received by Arduino MEGA hardware well.

In the Loop section, from the sketch program above can be analyzed, in the initial stage, do the analog readings through the jumper pin on the Arduino MEGA board (in this case the pin are A7 and pin A8). In the A8 pin is the input of the potentiometer in which the unit value is obtained, the value is 1 to 10,

then converted with a division of 10, to show the value of 1/10 until 1 second (which value of the number is integer) for the reading of the time unit according to adjusted accuracy.

On Pin A7 is an analog input derived from a voltmeter multitester cable, the red color indicates the positive sensor and the black color indicates a negative sensor. The value obtained from this analog input, the value are from 0 to 1023. Maximum value of 1023 are obtained because it is a provision of the Arduino with a reference voltage at 5 Volt, Then the input value in each pin, ranges from 0 to 1023. The value that has been obtained, then carried out the conversion by doing the calculation, in order to obtain the actual voltage value that is successfully detected by the sensor, In this case, which comes from both cable multitester voltmeters.

Readings are repeated 30 times or starting from index 0 to index 29, or according to the size of the reading limitation that specified in the Adjusted time unit, in every 1/10 second. Then each result that are obtained in that reading, displayed all in TFT LCD and the process keeps repeating as long as needed and should be displayed.

### 3.5.5 Oscilloscope Product Design Analysis

Reviewed from the product design, the product can be made easily and cost relatively inexpensive and because of its simple shape, It can be made for portable use, Because it consists of only a few simple components, As can be seen below:
☐ 1 piece of Arduino MEGA Board
☐ 1 piece of LCD TFT 2.4 Inch
☐ 1 piece of Switch Analog Input
☐ 1 piece of 10nf Potensiometer
☐ 1 piece of 9 Volt Power Suppy

Then to be able to function as needed, It is also easy to use and also easy to create and can be used in portable, Using several other tools, as can be seen below
• Laptop / Notebook
• Arduino IDE Software
• USB 2.0 Type A/B Cable
• TFT LCD 2.4 Inch
• 1 Pair of Cable Multitester Voltmeter (Positive & Negative)

The overall design of the product that has been created can be seen in the image below:
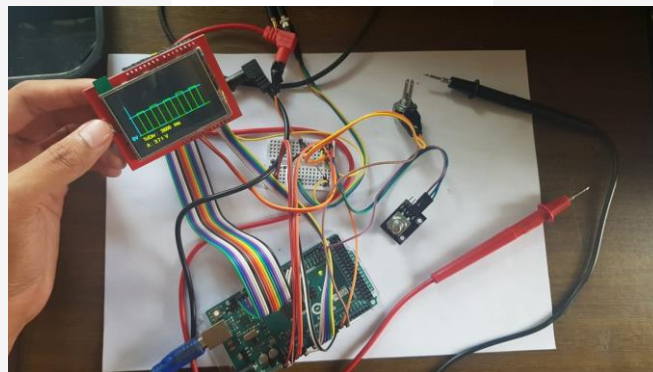
Figure 3.9 Product Design Oscilloscope

From the image above it can be seen that it only takes a few components, which are assembled using multiple jumper wires to connect some of the main components, Arduino MEGA and TFT LCD board, then another additional component, a pair of voltmeter cable Multitester that connects the positive and negative electric current of the object/power source. From the an Oscilloscope series, it can be seen that the actual design of the oscilloscope product is actually very simple and can be widely produced by the public with simple but effective and efficient methods and techniques which are proven to be used and used as a portable oscilloscope. This series can be equipped with a protective case so that the product can be used in conditions that are relatively vulnerable, but still functional.

3.5.6 IC555 Result Analysis to Portable Oscilloscope

After testing using the Training Kit Module using the IC555 component, the results of the response from the Oscilloscope product are obtained which can be seen on the TFC LCD display as follows below
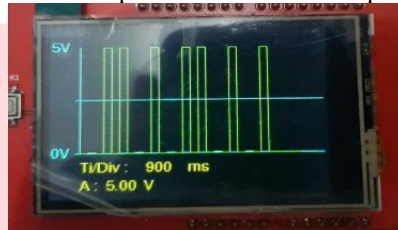
Figure 3.10 Output Postive Probe 3 output IC555

Figure 3.11 Output Postive Probe to LED 1 (RED)
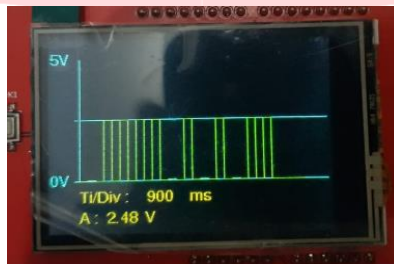

Figure 3.12 Output Postive Probe to LED 2 (YELLOW)

From figure 3.11 it can be seen that the results of the positive probe to LED 2 output indicate a decrease in the voltage measurement, this is because in the IC555 circuit there are several resistors used, so it can be analyzed that the oscilloscope product can work correctly, which is correctly measuring the voltage drop due to resistors, where the drop is 2.84 V from the reference voltage of 5 V. From other figures, namely figures 4.7 and 4.8, it can be seen that the oscilloscope product is functioning correctly, which can measure the maximum voltage which is the positive output of the probe according to the reference voltage used, which is 5 V.

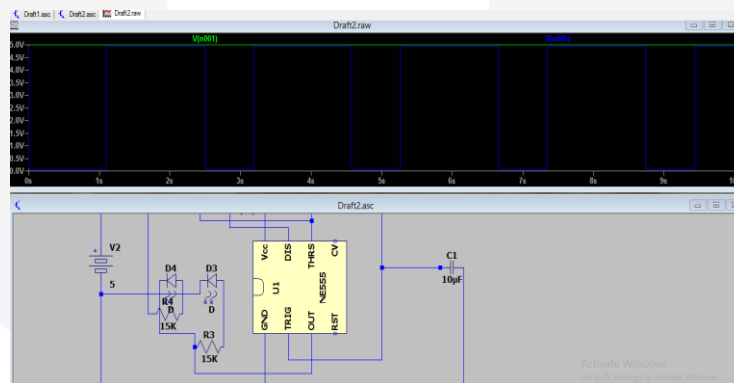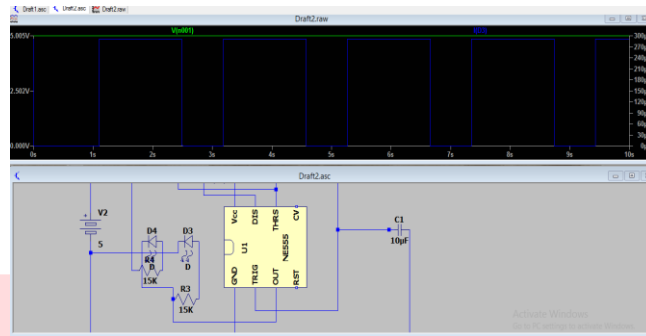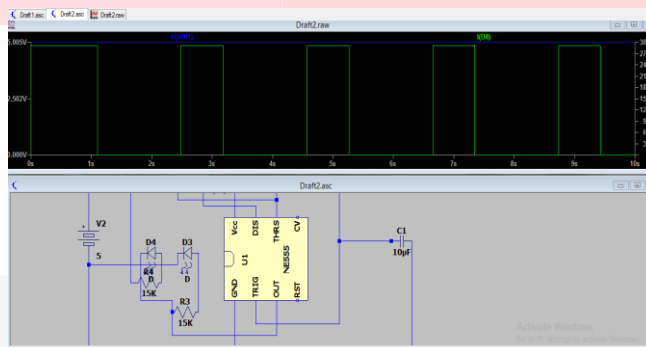### 3.5.6 IC555 Result Analysis Using LTSpice

Figure 3.13 Output 1 PIN 3 IC555

From the Figure above in output 1 Pin 3 IC555 using LT Spice, the value of 0 and 1 will change over time which shows the timer work.

Figure 3.14 Output 2 LED 1

From the Figure above in output 2 LED 1 using LT Spice, the value of 0 and 1 will change over time which shows the timer work. In 0 second the value will be 0 volt, then will change to 5 volt in 1 second.

Figure 3.15 Output 3 LED 2

From the Figure above in output 3 LED 2 using LT Spice, the value of 0 and 1 will change over time which shows the timer work. In 0 second the value will be 5 volt, then will change to 0 volt in 1 second.

3.5.7 Survey Analysis

In making a product, we have to do a survey analysis from several correspondent to obtain the results of the data and also can be used as an evaluation before marketing and selling the product. This is a customer satisfaction survey with the Oscilloscope that has been tested by each respondent. There are two types of questions for this survey, choices and opinions of the correspondents. These are some of the questions asked for respondents from the students of Telecommunication Engineering of Telkom University:

1. Apakah Produk ini berfungsi/berjalan dengan lancar?
2. Apakah Anda merasa terbantu dengan adanya Produk ini?
3. Apakah Anda puas dengan kualitas Produk ini?
4. Apakah Anda merasa tertarik dengan Produk ini?
5. Apakah anda merasa terbantu dengan adanya Produk ini? dan kenapa?
6. Aspek apa yang perlu kami perbaiki dari Produk ini?

Survey Table results from several respondents who willing to test the Oscilloscope Product:

Table 3.2 Oscilloscope Table Survey Analysis

No	Nama	Jurusan	Pertanyaan	SS	S	N	TS	STS
			Product Analysis Survey of Telecommunication Engineering Telkom University Student					
1	Ibnu Farhan	S1 Telekomunikasi	1. Apakah Produk ini berfungsi/berjalan dengan lancar?	√				
			2. Apakah Anda merasa terbantu dengan adanya Produk ini?	√				
			3. Apakah Anda puas dengan kualitas Produk ini?		√			
			4. Apakah Anda merasa tertarik dengan Produk ini?			√		
2	Gary Lineker	S1 Telekomunikasi	1. Apakah Produk ini berfungsi/berjalan dengan lancar?	√				
			2. Apakah Anda merasa terbantu dengan adanya Produk ini?		√			
			3. Apakah Anda puas dengan kualitas Produk ini?		√			
			4. Apakah Anda merasa tertarik dengan Produk ini?		√			
3	Mahendra Diwa	S1 Telekomunikasi	1. Apakah Produk ini berfungsi/berjalan dengan lancar?	√				
			2. Apakah Anda merasa terbantu dengan adanya Produk ini?	√				
			3. Apakah Anda puas dengan kualitas Produk ini?		√			
			4. Apakah Anda merasa tertarik dengan Produk ini?		√			

Table 3.3 Oscilloscope Table Survey Analysis

No	Nama	Jurusan	Pertanyaan	Jawaban
			Product Analysis Survey of Telecommunication Engineering Telkom University Student	
1	Ibnu Farhan	S1 Telekomunikasi	1. Apakah Anda merasa terbantu dengan adanya produk ini? Dan kenapa?	Iya, bisa melihat bentuk sinyal dengan jelas
			2. Aspek apa yang perlu kami perbaiki dari Produk ini?	Penambahan casing
2	Gary Lineker	S1 Telekomunikasi	1. Apakah Anda merasa terbantu dengan adanya produk ini? Dan kenapa?	Iya, dapat mempelajari sinyal yang sesuai
			2. Aspek apa yang perlu kami perbaiki dari Produk ini?	Masih ada delay dikit
3	Mahendra Diwa	S1 Telekomunikasi	1. Apakah Anda merasa terbantu dengan adanya produk ini? Dan kenapa?	Mengenali pola sinyal sesuai dengan voltasenya
			2. Aspek apa yang perlu kami perbaiki dari Produk ini?	Ditambahkan casing untuk lebih rapih

From the table above can be seen with a total of 3 correspondents, and the conclusions from the results of a survey that has been done is the majority of respondents agreed on proper functioning of the product, feel helped by the product, feel satisfied with the product, and one correspondent is neutral to feel interested to having the product.

3.5.8 Sales Price Analysis

In this Thesis, the method used in sales price analysis in our product is Markup Pricing method. Markup Pricing is a method to get the sale price of a product by adding a few percent of the price from the purchase of raw materials, Main purpose to use this Markup Pricing method is to make it easier to determine costs compared to estimating demand. In general, industrial companies use this method to minimize price competition[16]. We can calculate first how much initial capital is required before getting the markup price. The percentage that will later be the profit we get from a product.

$$\text{Selling Price} = \text{Capital Raw Material} + (\text{Capital Raw Material} \times \text{Markup})$$

Capital Raw Material

Table 3.4 Capital Raw Material Table Analysis

No	Component	Quantity	Price	Amount of Price
1	LCD TFT 2.4 Inch	1	Rp. 70.000	Rp. 70.000
2	Arduino Mega Board	1	Rp. 600.000	Rp. 600.000
3	Cable Multimeter Tester(Positive/Negative)	1	Rp. 8.000	Rp. 8.000
4	9 Volt Power Supply	1	Rp. 25.000	Rp. 25.000
5	Potensiometer 10 kilo ohm	1	Rp. 3.000	RP. 3.000
6	Switch Analog Input	1	Rp. 4.000	Rp. 4.000
7	100nf Capacitor	1	Rp. 500	Rp. 500
8	10 kilo ohms Resistor	1	Rp. 300	Rp. 300
9	Arduino White Board	1	RP. 10.000	Rp. 10.000
10	Stereo Female Jack Connector	1	Rp. 10.000	Rp. 10.000
11	Cable Male to Male 3.5mm Stereo Jack	1	Rp. 35.000	Rp. 35.000
12	Jumper Male to Male	38	Rp. 1.000	Rp. 38.000
	Total			**Rp. 803.800**

From the Table 4.4 Above, the Capital Raw Material for our Product is Rp. 803.800, and the Markup we want to add is 20 % because to attract the customer with the affordable price with a massive production. So, the profit that we can get is Rp. 160.000/Product, and the selling price Rp. 965.000/Product.

Selling Price = Rp. 803.800 + (Rp. 803.800 x 20%)
Selling Price= Rp. 965.000/Product

4. Conclusions and Suggestions

4.1 Conclusions

From product design, product manufacture and product testing can be proven that by using Arduino technology can be made product design that can be used to make oscilloscope. From the design of the product, it can also be used portable. The product design can be proven to function operationally using a pair of cable multitester Volmeter to connect the positive and negative electric current of the object/power source with a maximum voltage of 5 Volts. From product design, product manufacture and product testing can also be concluded that the Oscilloscope products using the Arduino technology can be easily used and made at a relatively inexpensive cost and can be used on a portable basis. From the test results it turns out to use only a few tools with relatively affordable cost to create the Oscilloscope product design, which can function properly. The design of this product is also proven to be used as an alternative design product Oscilloscope for electrical signal measurement needs. Because the product design is easy to use and made with relatively inexpensive cost, it can be utilized by more people, and for the future can be used for the development of similar products or other research.

4.2 Suggestions

By enhancing the design of this Oscilloscope product by using more quality components, it is recommended that this product design can be the basis for the manufacture of products that can be manufactured in the manufacturing industry or can also be in small medium enterprises. Another product design is recommended for use in combination with other devices, because it still open the gap to make this product design more perfect and developed with higher technology implementation but still low cost.

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