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Design of Acoustic Transmission Loss Measurements in the Form of Power Amplifier Based on Impedance Tube Method

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ABSTRACT
The conventional amplifier involves a power supply (ground) line connected to the audio path. This In the processing of the audio signal will appear IHM (Interval Hum Modulation) noise. Therefore, to be able to suppress the occurrence of noise to a minimum, then made an amplifier that does not refer to a ground power supply. The amplifier must really balance from input to output. To realize the balance amplifier is specified class AB push-pull specification with arms power of 120 Watt and bandwidth width between 50 to 10kHz. In the power amplifier used complementary pairs circuit system as a current amplifier. Based on the test results turned out output power to the speaker only 100 Watt with 20 volt supply voltage and has a bandwidth width between 30 Hz to 15 Hz with a gain of 163 times.

Keywords : ***Balance Amplifier, Push-Pull, Class AB, Tube Impenddance***

INTRODUCTION

The power amplifier is the final amplifier of the sound system that functions as an audio signal amplifier which is basically a voltage and current amplifier of an audio signal which aims to improve the sound.(Roihan et al., 2020). Where the term power amplifier is the final amplifier so it is not equipped with a different tone regulator with the term amplifier which consists of a tone regulator and a power amplifier.(Aryza et al., 2018). Audio is defined as sound or sound reproduction. Sound waves are waves produced by a vibrating object. The picture is a plucked guitar string, the guitar will vibrate and this vibration propagates in air, or water, or other materials. The only place where sound cannot propagate is a vacuum. This sound wave has valleys and hills, one valley and hill will produce a cycle or period(Adawiyah et al., 2013).

This cycle is repeated, which leads to the concept of frequency. Obviously, frequency is the number of cycles that occur in one second. The unit of frequency is Hertz or Hz . for short(Pritama & Andrasto, 2014). The human ear can hear sounds between 20 Hz to 20 KHz (20,000Hz) within the limits of the audio signal. Because basically audio signals are signals that can be received by the human ear. The number 20 Hz is the lowest audible sound frequency, while 20 KHz is the highest audible frequency. The utilization of audio signals provides employment in the field of audio signal production including, recording, signal manipulation and sound wave reproduction.(Apriansyah et al., 2016). Audio theory is simpler than video theory and it is commonly understood the basic pathways of sound sources, sound equipment for hearing, it all starts with making senses. As a technical note, physically sound is a form of energy known as acoustic energy. Therefore, a reliable audio amplifier is needed to support the development of research in the audio field(Dumond & Johnson, 2013).

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LITERATURE REVIEW

Active Components (Transistors)

Transistor is an active component made of a semiconductor material. There are two kinds of transistors, namely the bipolar transistor and the field effect transistor (FET).(Engineering, 2014). Transistors are used in circuits to amplify the signal, meaning that a weak signal at the input is converted into a strong signal at the output(Mr. Punit L. Ratnani, 2014).

Passive Components (Capacitors)

Capacitors function to withstand DC current and as a coupling (connector) and store current. The capacitor consists of:

a. ComponentsElectrolyte
b. ComponentCeramic
c. Mica Components
d. Tantalum Components
e. ComponentVariable

Frequency

Frequency is an objective physical phenomenon that can be measured by acoustic instruments. Frequency is a measure of the number of repetitions per event in a given time interval. To calculate frequency, one sets a time interval, counts the number of occurrences of events, and divides this count by the length of the time interval.The results of this calculation are expressed in hertz (Hz) which is the name of the German physicist Heinrich Rudolf Hertz who discovered this phenomenon for the first time. increasing human age. Human audio frequency range will be different if the human age is also different.

The magnitude of the frequency can be determined by the formula:

$$f = \frac{1}{T} \text{..}$$

where: *f = Frequency (Hz)*
T= Time (seconds)

Where Period is the number of times per number of vibrations, so the period is inversely proportional to the frequency(Lubis et al., 2018).

$$T = \frac{1}{F} \text{..}$$

where: *f = Frequency (Hz)*
T = Time (seconds)

Sound Transmission Loss

Sound transmission lossis the ability of a material to reduce sound. The value is usually called the decibel (dB). The higher the value of sound transmission loss (TL), the better the material is in reducing sound (Bpanelcom 2009). Sound transmission class(STC) is the average

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transmission loss ability of a material in reducing sound of various frequencies. The higher the STC value, the better the material in reducing sound (Bpanelcom 2009). The STC value is determined based on the ASTM E 413 quality standard regarding the Classification for Rating Sound Insulation issued by the American Society for Testing and Materials (ASTM)

Balance Amplifier

In general, conventional amplifiers involve a power supply ground line that is connected to the audio line. So that in audio signal processing, IHM (Interval Hum Modulation) noise will appear. This hum noise mainly comes from the power supply, namely the rest of the 50Hz grid voltage ripple that flows into the ground line and then goes back into the amplifier input. In addition, IHM can also come from the movement of the speaker cone which causes an opposing induced emf on the ground line. Residual ripple and speaker induced emf causes the ground path that should be zero to be incompletely zero. IHM results from conventional amplifiers cover the audio frequency field from 20 Hz to 20 kHz. audio signal. Since this amplifier is not ground referenced, IHM(Yosi Darmawan Arifianto, 2018)

To reduce the hum noise, it is necessary to use an amplifier that is truly balanced from input to output. As shown in Figure 2, this amplifier balance does not involve the power supply ground path which becomes small. Where this balance amplifier uses a symmetrical circuit both from the power supply, input and output without involving the ground line at all. The IHM balance amplifier chart decreased by 40 db from 200 Hz to 20 KHz.

METHODS

Tools and Materials As for the equipment used during this research are:

1. Laptops
2. LabJack U3-LV
3. Amplifier
4. Speakers
5. Microphone
6. Tube impedance

Material

The specimen material used in this study was Aluminum-Magnesium (Al-Mg) with a thickness of 10 mm. The variety of specimens used in the study is shown in the image below.

Experimental Set Up

The transmission loss test is carried out using 4 microphones, in contrast to the sound absorption coefficient test which only uses 2 microphones. The schematic and setup of the tool for testing transmission loss is shown in the figure below. This research study is the design of making an audio amplifier for measuring transmission loss. Where the process of making this design which consists of determining the circuit system that will be tailored to the needs. The composition of the building blocks is planned as a controller amplifier (driver), final amplifier (current amplifier) and power supply.

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Testing Procedure

The testing procedure carried out is as follows:

1. Prepare all test equipment by setting according to the test equipment set up drawings.
2. Insert the test specimen in the impedance tube, which is in the middle of the test chamber with a position perpendicular to the direction of the tube space.
3. Measurements were made at the frequencies of 125Hz, 250Hz, 500Hz, 1000Hz, 1500Hz, and 2000 Hz.
4. Connect microphones 1, 2, 3, and 4 to the mic pre-amp channels 1, 2, 3, and
5. Connect the mic pre-amp channel outputs to channels 1, 2, 3, and 4 on the labjack.
6. Connect the Labjack to the USB port on the Laptop then open the DAQFaqtory Software to analyze the signal.
7. In DAQFaqtory open the Sound Recorder 4ch program.
8. To generate an audible signal, open the ToneGen program. The sound that is issued is pure tone.
9. Set the frequency on ToneGen and then reopen DAQFaqtory to see a graph of the sound voltage on each microphone.
10. Click Start/Stop Save for Logging data. Graphic data will be automatically saved in the drive (D:) on the laptop.
11. Take the average voltage value on each microphone (1, 2, 3, and 4) to calculate the transmission loss value with the help of MATLAB.
12. Calculate the sound pressure on each microphone with the formula
13. Calculate the sound pressure ratio between microphones using the formula:
14. Calculate the value of Transmission Loss with the formula:
15. Repeat the above procedure for different frequencies and samples.
16. Enter the calculated data into a table and plot it into a graph in order to see the comparison of transmission loss at different frequencies and in each sample.

RESULTS AND DISCUSSION

The following is a data transmission loss test results for various variations of aluminum-magnesium alloys.

1. Alloy 98%-Mg 2%

   The value of transmission loss for 98%-Mg 2% Al alloy can be seen in table 1.

   The balance amplifier applied is a current amplifier with the following specifications:

   - Power rms(Prms)=100 w
   - Output impedance= 8
   - db ranging from 200 Hz to 20 kHz frequency.

   From the results of the calculation of Transmission Loss (TL), it can be directly plotted the graph of the transmission loss so that it is easier to conclude the results of the analysis from the tests that have been carried out, as shown in the figure below.

2. Alloy 96%-Mg 4%

   The value of transmission loss for Al 96%-Mg 4% alloy can be seen in table 1.

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Table 1. Table of transmission loss for Al 96%-Mg 4% alloy

Frequency (Hz) Transmission Loss (dB)
125 23.6355
250 29.8582
500 29.9082
1000 35.1686
1500 42.1993
2000 34.2137

In graphical form, the transmission loss of Al 96%-Mg 4% alloy can be seen in Figure 1.

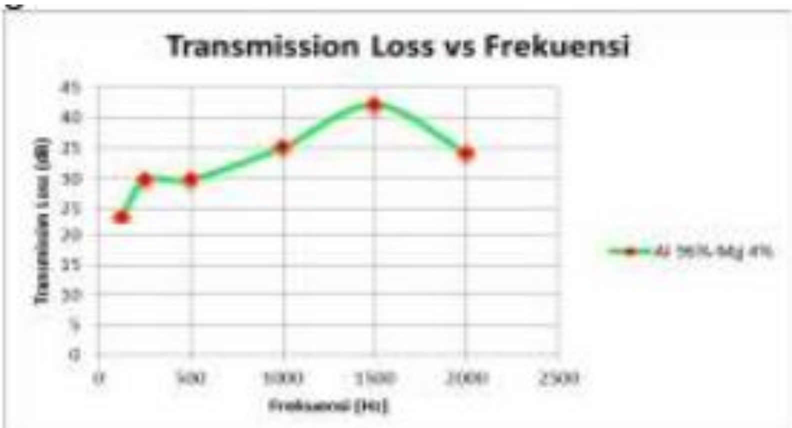

Figure 1. Graph of transmission loss of Al 96%-Mg 4% alloy.

3. Alloy 94%-Mg 6% The value of transmission loss for alloy Al 94%-Mg 6% can be seen in table

Table 2. Table of transmission loss for Al 94%-Mg 6% alloy.

Frekuensi (Hz)	Transmission Loss (dB)
125	20.7008
250	27.3955
500	28.2449
1000	32.3890
1500	33.4028
2000	27.5394

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In graphical form, the transmission loss of Al 94%-Mg 6% alloy can be seen in Figure 2.

Figure 2. Combined transmission loss graph Al 94%-Mg 6%.

From some of the pictures above, it can be seen that the transmission loss values are different for various frequency variations that have been determined with the same thickness, which is 10 mm thick. Figure 10 above shows that the maximum TL value in each Al-Mg alloy specimen occurs at the same frequency, namely 1500 Hz and the minimum TL occurs at the same frequency, namely 125 Hz. In the 98%-Mg 2% Al specimen the highest TL value was 45.0191 dB and the lowest TL value was 25.0690 dB. For specimens Al 96%-Mg 4% the highest TL value was 42.1993 dB and the lowest TL value was 23.6355 dB. For specimens Al 94%-Mg 6% the highest TL value was 33.4028 dB and the lowest TL value was 20.7008 dB. It can be concluded that the frequency greatly affects the size of the TL value in the measurement of an acoustic material.

CONCLUSION

In testing the signal observation on the oscilloscope, the noise in the balanced power amplifier is smaller than that of the unbalance power amplifier. Based on the results of the hearing test, there is still noise in the balance power amplifier. The amplification results at different frequencies produce different output voltage amplitudes. Based on the test results, it turns out that the output power that comes out to the speaker is only 100 Watts with a supply voltage of 20 volts and has a wide bandwidth between 30 Hz to 15 Hz with a voltage gain of 160.75 times and a calculation of 163 times. The use of components should have good quality to avoid noise, especially in the use of coax cables. The oscilloscope settings are adjusted to the needs so that the data output is clearer.

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