Nigerian Journal of Physics (NJP)

ISSN: 1595-0611

Volume 32(3), September 2023

Design and Construction of 30.25 Watts Audio Power Amplifier

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Keywords:
Audio,
Power,
Amplifier,
Distortion,
Efficiency.

ABSTRACT

Audio power amplifiers are electronic circuit that boost or strengthens an input signal by providing amplification. The nature of the signal could be any of the following: voltage, current or power. In the present-day era, most, small and medium size electronic devices used integrated circuit chip to perform audio power amplification. The paper designed and constructed 30.25 W audio power amplifier using TDA2040 module from the circuit digest. The simulation of the circuit was carried out using proteous 8 professional. The power supply unit was constructed using 12V-0-12V center-tap step-down transformer and thereafter the amplifier. The results of the device showed that the amplifier exhibited low distortion. The output power and efficiency were found to be 30.25 watts 78.5 % respectively. Furthermore, the agreement between the simulated and experimental result confirms the good performance of the amplifier.

INTRODUCTION

Rahman and Razzak (2012) and Olivera (2000), defined 'audio power amplifier as an electronic instrument that increases low-power electronic audio waves or signals from radio receiver to a certain stage that is high enough to drive loudspeakers or headphone'. Furthermore, they are automatic devices that increases the input signals. Amplification on the other hand, is regarded as the process of increasing the size (magnitude) of a variable quantity especially the magnitude of a voltage or current, without substantially changing or altering any other quality) and the nature of the signal could be of any type such as voltage, current or power of a circuit (Oti & Ahanonu 2015). A typical amplifier usually consists of a number of stages that strengthens a weak or feeble signal (wave) until adequate power is available to operate a loudspeaker or other output devices. The few stages in a multistage amplifier have the function of only voltage amplification. However, the last stage is designed to provide maximum power. This final stage is known as power stage. (Mehta, 2008).

Amplifiers are automatic circuits that magnify or enlarge an input signal, by providing amplification; the description of the signals could be any of the following: voltage, current or power (Cordell, 2011). More so, an amplifier can be considered as a case or box carrying the amplifying devices such as transistors, operational amplifiers, diodes, resistors etc., with an output signal being much greater than that of the input signal (Cordell, 2011 & Otasowie *et al.*, 2015).

The word 'audio' refers to the spectrum of frequencies which our ears can hear and ranges between 20-200KHz. As such, audio amplifiers amplify electrical signals that have a frequency range corresponding to the range of human hearing i.e. 20-200KHz, to a level suitable for driving loudspeakers Mehta (2008).

Lee De Forest (who is regarded as the father of amplifier), was the first to use an instrument that could amplify sound. He invented the triode vacuum tube in 1906 (a triode is a three-terminal device with a control grid that can modulate the flow of electrons from the filament to the plate). According to Rahman and Razzak (2012), 'Early audio amplifiers were based on vacuum tubes commonly called valves'. The vacuum tubes were broadly in used in virtually all amplifiers until between 1960-1967 when they were replaced by transistors.

Today, most amplifiers used transistors with chips (IC) but vacuum tubes continue to be used in some applications (Rahman & Razzak, 2012). Nowadays, audio amplifiers are based on solid-state devices (transistors such as BJTs, FETs and MOSFETs). Audio amplifiers based on transistors became real, availability and affordable in the late 1960s (Oti & Ahanonu, 2015).

In the present-day epoch or era, most, small and medium size electronic devices uses integrated circuit chips to carry out audio power amplification operations which is contrary to the famous or well-known belief

that those audio power amplifiers are no longer in use (obsolete). Hence, this study seeks to justify the claim that audio power amplifiers are still being used broadly in large transmitters and quality audio amplifiers. The aim of the study is to design and construct an audio power amplifier using an integrated circuit chip, that will provide more amplification alternatives that is cheaper, reliable and easily accessible in audio electronic Industries. The significance of this study is that, it will provide more amplification options that is cheaper, reliable and easily accessible in audio electronic Industries.

The broad objectives of this study, is to design and construct an audio power amplifier using an integrated circuit chip while the specific objectives of the study are to: design the circuit diagram, simulate the circuit and construct an audio power amplifier.

MATERIALS AND METHOD

The construction of the amplifier was based on the circuit simulated. First, the power supply unit was constructed based on the specification of the proposed amplifier. The device will need almost ± 17 v power supply on rail. Thus,

$V_{ref} = V_{rms}$ x $\sqrt{2}$, *where* V_{rms} = 12v, therefore V_{ref} ~16.9v.

The next step was to convert or change the alternating current (a.c.) into a direct current (d.c.) using a rectifier circuit with bridge configuration of four diodes of 1A each and two capacitors (each of 330µf) to filter the ac unwanted ripples from the pure d.c. signal in order to get a pure dc voltage to be fed into the system. Then it was followed by the construction of the amplifier. A blue print of the amplifier was first drawn on a sheet of paper and was then used as a guide to solder all the components to the Vero board. Air gap were avoided as much as possible while soldering the various components. The constructed audio power amplifier was then tested and cased.

The Power Supply Unit

The audio power amplifier shall be using dual rail power supply. Hence, this unit used a step-down transformer of the rated voltage having a center tap output or secondary. The secondary side shall be using a bridge rectifier and smoothening capacitors. The configuration takes the dual rail power supply and uses two capacitors.

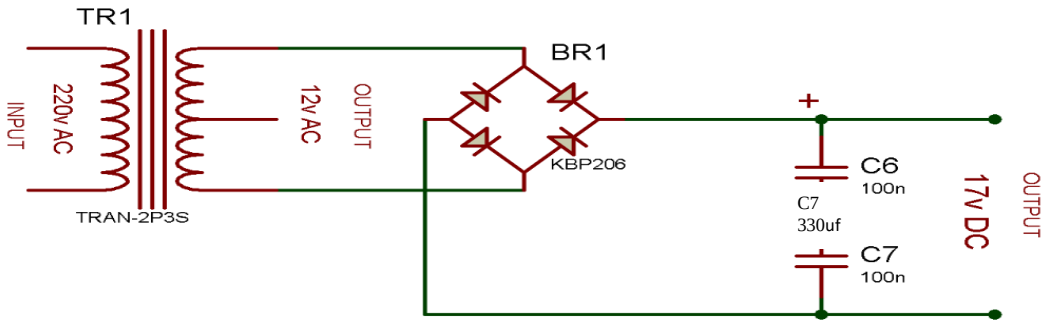

Figure 1: Power Supply Unit.

The Circuit Diagram with the Power Supply Unit

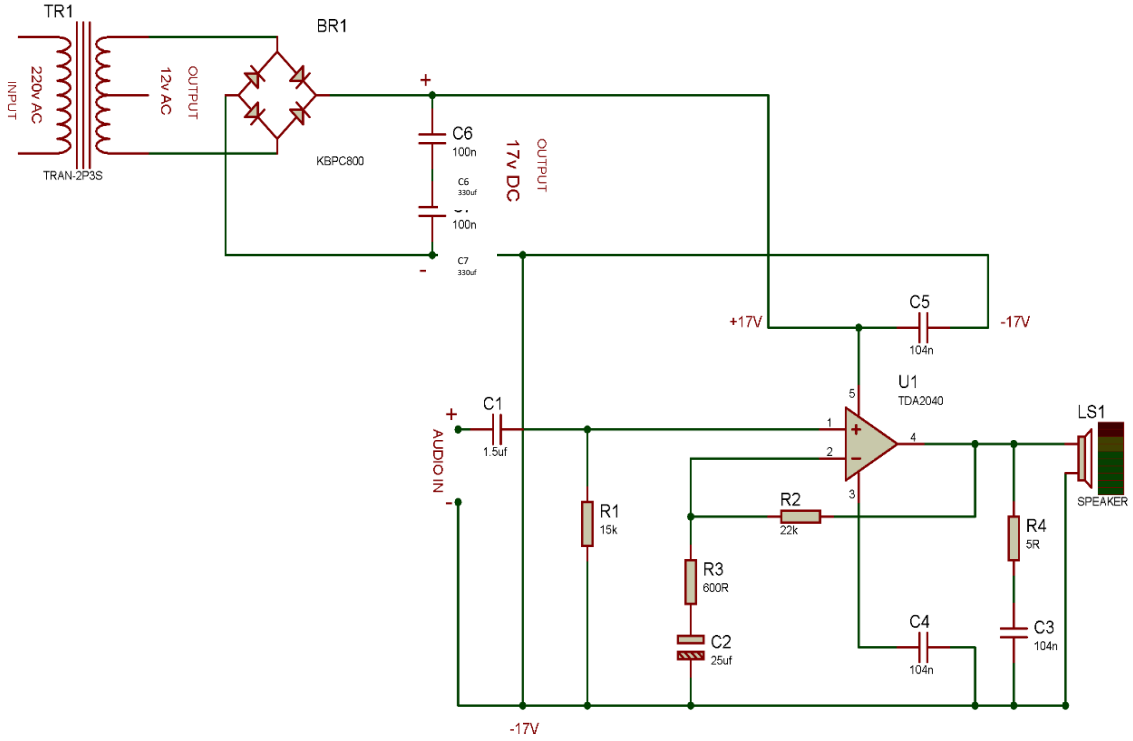

Figure 2: Circuit Diagram of the Amplifier

RESULTS AND DISCUSSION

Simulation

The simulated result was shown below:

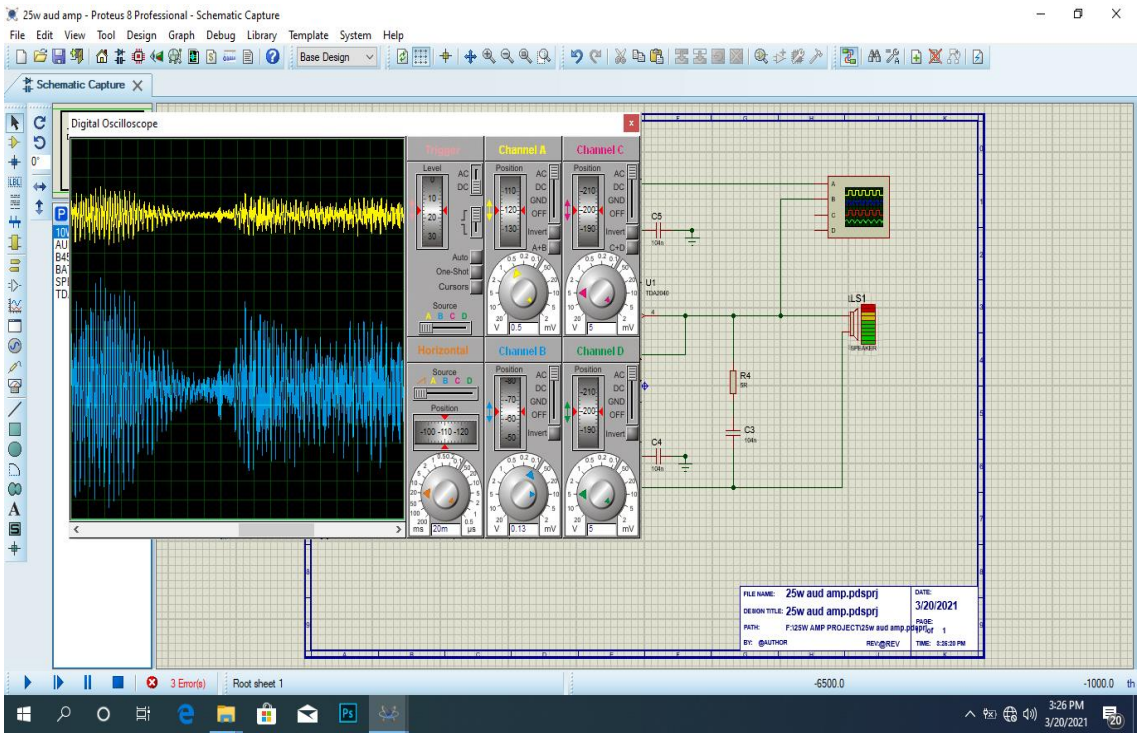

Figure 3: The Simulated Circuit.

Constructed Audio Power Amplifier

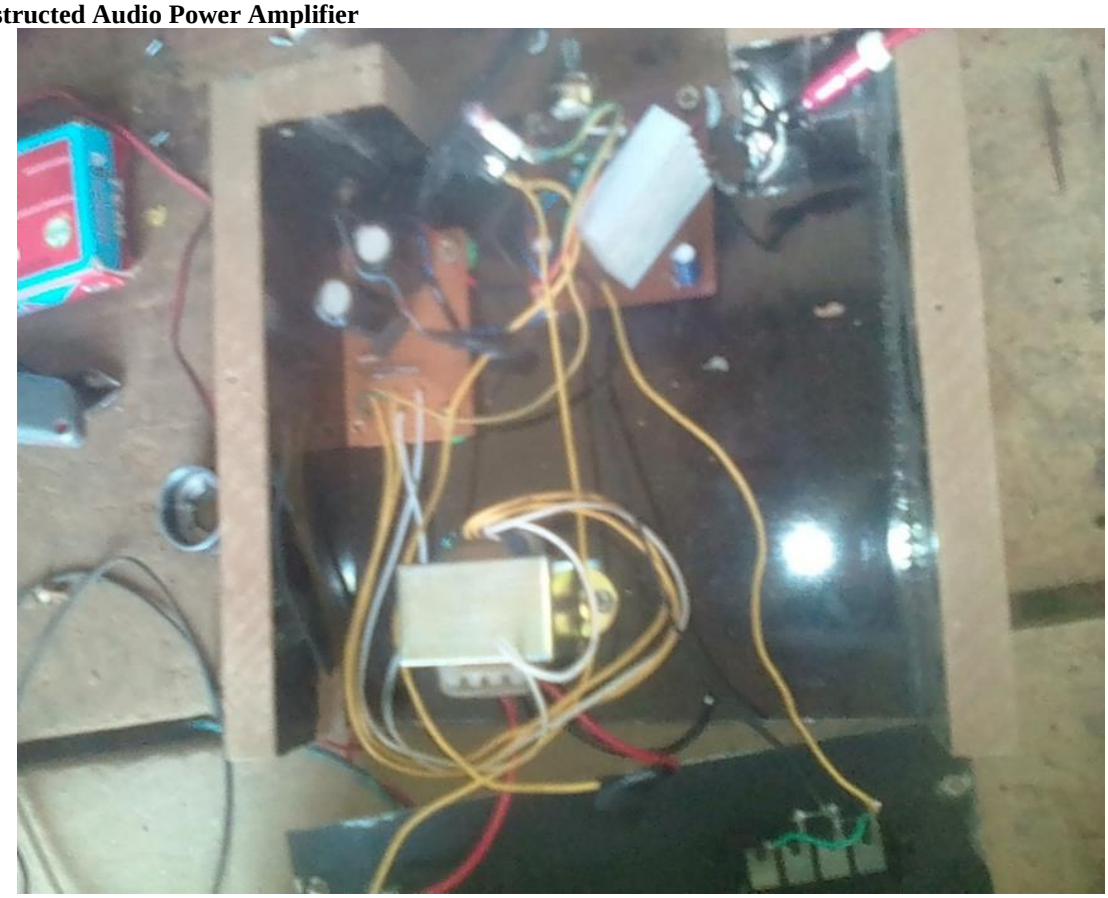

Figure 4: The Constructed Amplifier (30.25W).

Input Voltage Waveform before Amplification

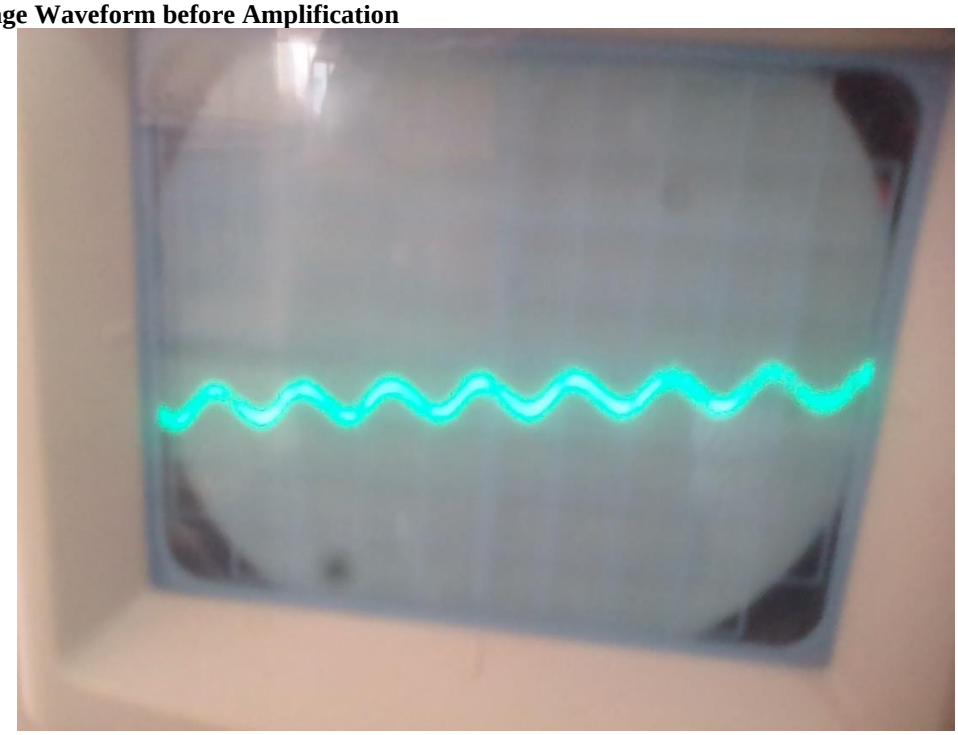

Figure 5: Input Voltage Waveforms

The scale used was set at 0.2V and then the peak-peak voltage was measured.
V_{p-p} =$\frac{1}{2}$ x 2 x 0.2 = 1 x 0.2 = 0.2V.

Input Voltage, $V_1 = 0.2V$ (Before Amplification)
Output voltage, V_2 = 2.25V after Amplification

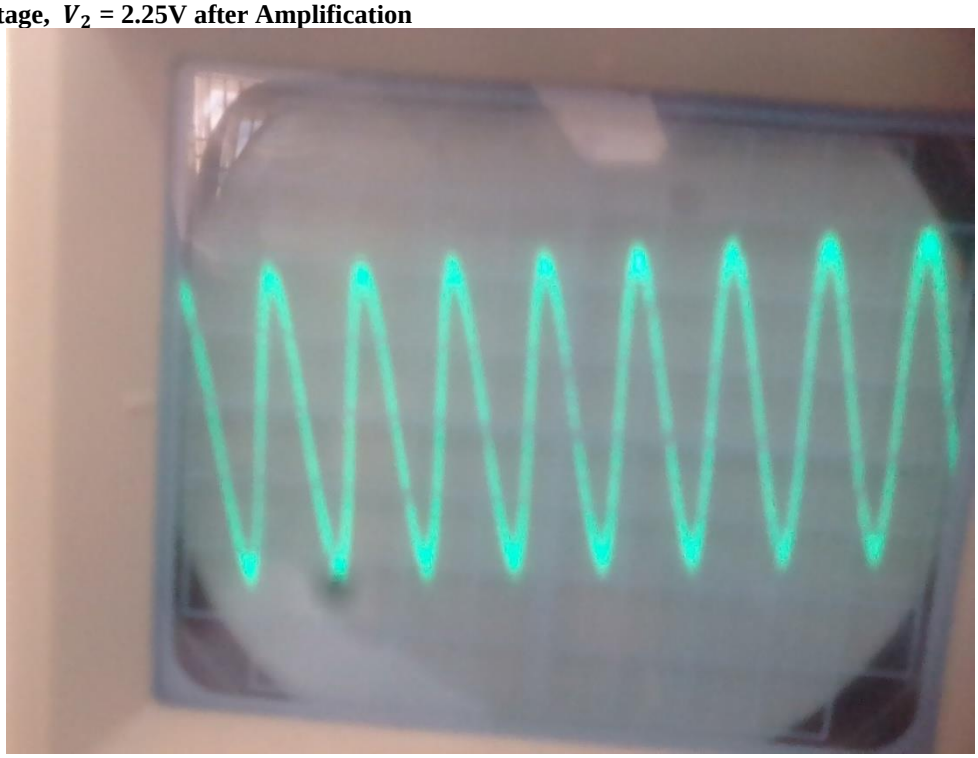

Figure 6: Output Voltage Wave forms.

The peak voltage is, V_{p-p} =1 x 4.5 x 0.5 = 2.25V.

Output voltage, V_2 = 2.25V after Amplification
Numerical Results

i. Wattage power, $P_0 = {V^2}/{R}$, where V and R being voltage and resistance respectively. V is the voltage gain = ${V_2}/{V_1} = {2.25}/{0.50}$, V= 11.25v and R=4Ω. ∴ P_0 = **30.25w**

ii. Efficiency = ${P_{0\ (ac)}}/{P_{i\ (dc)}}$ X 100%, where $P_{0\ (ac)} = {V\ cc^2}/{2R} = {12^2}/{2X4}$= **18**

$P_{i\ (dc)} = {2\ V\ cc^2}/{\pi R} = {2\ X12^2}/{3.142X4}$=**22.92**

∴Efficiency= **78.5%**

iii. . Gain of the amplifier = ${R_2}/{R_3} = {22{,}000}/{600}$ = **36.67**

iv. Amplifying factor, A_f = ${R_2}/{R_3}$ + 1 = **37.67**

Discussion

From the audio power amplifier designed and constructed using the TDA2040 showed a satisfactory result. The amplifier was capable of driving 30.25 watts of power into a 4-ohm speaker when a voltage supplies of ±17V was used. The amplifier's efficiency was found to be 78.5% though the amplifier was believed to have a distortion of 10%, which was still very low and very low noise level. This result, was similar to the results obtained by Otasowie *et al*. (2015), who worked on similar device capable of driving 30.25 watts into an 8-ohm speaker. The designed and developed public address audio amplifier reveals the input and output power to be 42 watts and 30.25 watts with 78.5 % as its efficiency and Rahman & Razzak (2012), who designed and developed audio power amplifier but using a different IC, LM1875. The amplifier was able to deliver 25 W (which corroborates with the proposed wattage) with same efficiency (78.5 %). However, a slightly different result was recorded by an Anonymous (2019)

who designed and constructed a public address system using TDA2030. The overall performance was quite good but it has a noisy reception. The same is the case with Ben (2000) who designed and constructed a stereo amplifier and found the chosen design performing almost perfectly to specifications with distortion when simulated in the Microsim PSPICE™ circuit simulator but under actual construction there was higher amplification. The circuit was an overall success but things did not work out as originally planned. Additionally, the experimentation with power amplifier resulted in the destruction of many NPN, PNP and BJT's.

In a nutshell form, the result got from both simulation and the constructed amplifier were in agreement with each other, though it was ensured prior to the construction. 30.25 watts was found to be capable of driving a 4-ohm load (speaker) using TDA2040 on a dual rail of ±17 V. The efficiency, gain and amplifying factor were 78.5 %, 36.67 and 37.67 respectively which confirms the reliability of the amplifier.

CONCLUSION

This study, designed and constructed audio power amplifier using TDA2040. Simulation of the circuit yielded a satisfactory result, although this was ensured before the actual construction and that, the agreement between the simulated and experimental result confirms the good performance of the amplifier and has further justified the claim that 'audio power amplifiers are still being used widely in large transmitters and high-fidelity audio power amplifiers'. The study further recommended that, other researchers should advance the course of the research by implementing a stereo system using the same IC chip (TDA2040), the manufacturing industries should key in to using IC chips as an alternative method of amplifying power other than using solid-state transistors, considering among others advantages of portability, occupy less space, availability and its reliability in producing quality audio amplification and the system should be incorporated with more features that will produce higher power than 30 watt using same chip.

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