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Design and Construction of 200W OCL Audio Power Amplifier

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Abstract: *The primary goal of sound system facility for lecture room is to deliver clear, intelligible speech to each canditate. To reach this goal, the DC-coupled amplifier based on output capacitor-less (OCL) system is used. This paper presents the design and construction of 200W OCL audio power amplifier for lecture room. The design analysis is described and procedures for design implementation are presented. Each of the implementation is evaluated and these evaluations lead to the conclusion that the design is able to achieve high efficiency with acceptable sound quality. The overall efficiencies of various input frequencies were achieved above 88%. The Multisim software is used for the simulation of audio power amplifier.*

Key Words: *DC-coupled, OCL system, Multisim software.*

1. INTRODUCTION:

An audio amplifier has been described as an amplifier with a frequency response from 20 Hz to 20 kHz. Audio amplifiers play important role in audio system. An amplifier is an electronic circuit which increases the magnitude of the input signal. An amplifier can be classified as a voltage, current or power amplifier. An OCL (output capacitor-less) amplifier is any audio amplifier with direct-coupled capacitor-less output. Typically, OCL amplifier can be any of several amplifier classes, and typically have a push-pull output stage. Advantages of OCL amplifiers over capacitor-coupled amplifiers include

- Avoiding the cost and bulk of an output capacitor
- Better immunity to motorboat oscillation
- Larger output power at very low frequencies and DC [9]

A basic sound reinforcement system consists of an input device (microphone), a control device (mixer), an amplification device (power amplifier), and an output device (loudspeaker). Fig.1.1 shows a complete sound system. Sound waves are converted into an equivalent electrical signal by the microphone. This microphone level signal is amplified to line level and possibly combined with signals from other microphones by the mixer. The power amplifier then boosts the line level signal to loudspeaker level to drive the loudspeakers, which convert the electrical signal back into sound.

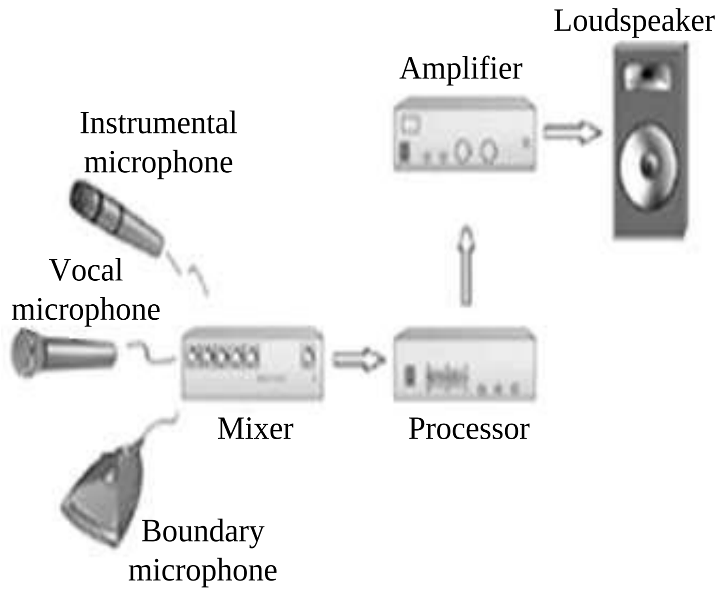

Figure 1.1. Complete Sound System [3]

The vast majority of audio amplifiers use the conventional architecture in which there are three stages, the first being a transconductance stage or input stage (differential voltage in, current out), the second a transimpedance stage or voltage amplifier stage (current in, voltage out) and the third a unity-voltage-gain output stage. [2]

1.1 Input Stage

The differential amplifier is used as pre amplifier in input stage. It eliminates the need for an emitter bypass capacitor. There are no coupling or bypass capacitors, there is no lower cutoff frequency.

1.2 Voltage Amplifier Stage

The stage that precedes the output stage is called a driver. Rather than capacitive couple into output push-pull stage, it is used the direct-coupled CE driver. It uses the output current from pre amplifier stage and produces the voltage to drive the output amplifier. The collector current out of the driver sets up the quiescent current through the complementary diodes.

1.3 Output Stage

The complementary class B push-pull amplifier is used to produce required output. In a class B push-pull emitter follower, complementary npn and pnp transistors are used. The npn transistor conducts on one half cycle and the pnp transistor on the other. To avoid crossover distortion, the transistors of a class B push-pull emitter follower have a small quiescent current.

2. METHODOLOGY:

To design the 200W audio power amplifier, the following steps were taken : (i) Selection of components (ii) Analysis of audio power amplifier (iii) Simulation of audio power amplifier using Multisim software (iv) Construction of audio power amplifier and (v) Testing

2.1 Selection of Components

At every stage in the design of an amplifier, it is perhaps wise to consider whether bipolar junction transistors (BJTs) or field effect transistors (FETs) are the best devices for the job. The BJT is the most convenient for all three stages of a generic power amplifier due to the fact that the predictable V_{be} (base to emitter voltage)/I_c (collector current) relationship and much higher transconductance of BJT.

2.2 Analysis of Audio Power Amplifier

For required output power $P_{out} = 200W$ and speaker load $R_L = 4\Omega$, the power supply voltage can be calculated using the Equation 2.1. [3] Therefore 40V of power supply voltage is calculated.

$$P_{out(max)} = \frac{MPP^2}{8R_L} = \frac{(2V_{CC})^2}{8R_L} \tag{2.1}$$

The overall voltage gain is achieved by using Equation 2.2. Where $V_{out(rms)}$ is the output rms voltage and $V_{in(rms)}$ is the input rms voltage. [3]

$$A_V = \frac{V_{out(rms)}}{V_{in(rms)}} \tag{2.2}$$

$V_{in(rms)} = 2.5/2\sqrt{2}$ (Choose standard maximum input)

$$P_{out(rms)} = \frac{V_{out(rms)}{}^2}{R_L}$$

$$V_{out(rms)} = 28.28V$$

$$A_V = 20\log_{10}\frac{28.28}{0.884} = 30.1dB$$

Therefore the overall voltage gain of 30.1 dB is achieved. Similarly, speaker (sound) power is achieved by using the following equation;

$$P_{out} = \frac{V_{out}{}^2}{R_L} \tag{2.3}$$

$$100 = \frac{V_{out}{}^2}{8}$$

$$V_{out} = 28.28V$$

$$V_{out} = 1V \rightarrow V_{out(actual)} = 0.7V$$

$$V_{out} = 28.2V \rightarrow V_{out(actual)} = 19.8V$$

$$\therefore \text{Speaker(sound) power in rms value} = \frac{{V_{out(actual)}}^2}{R_L} \approx 50W$$

2.3 Simulation of Audio Power Amplifier

Before constructing the overall system, it was tested by using Multisim software.

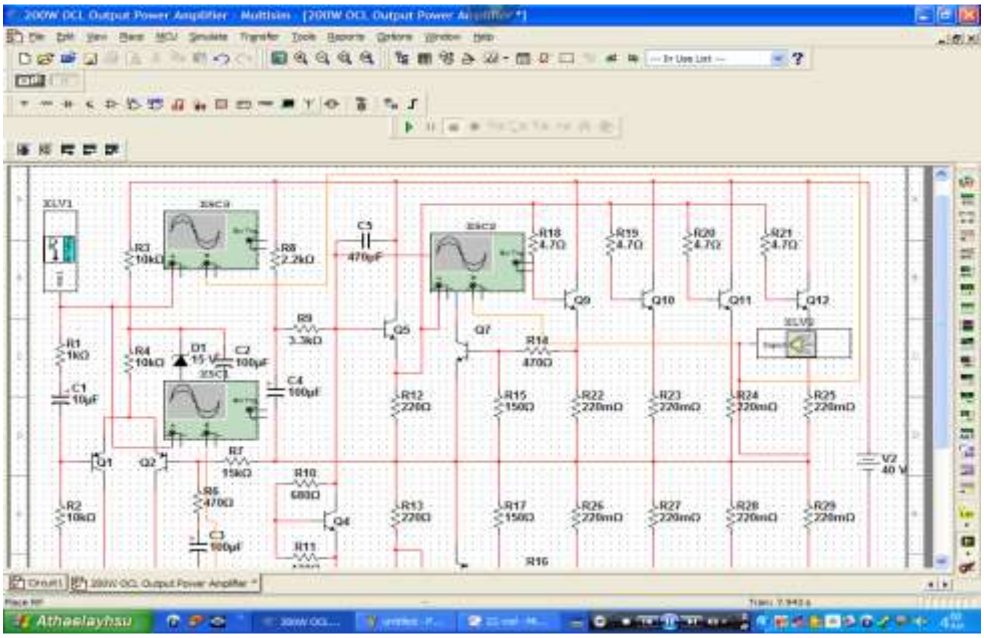

Figure 2.1. Screenshot of Audio Power Amplifier

2.4 Construction and Testing of Audio Power Amplifier

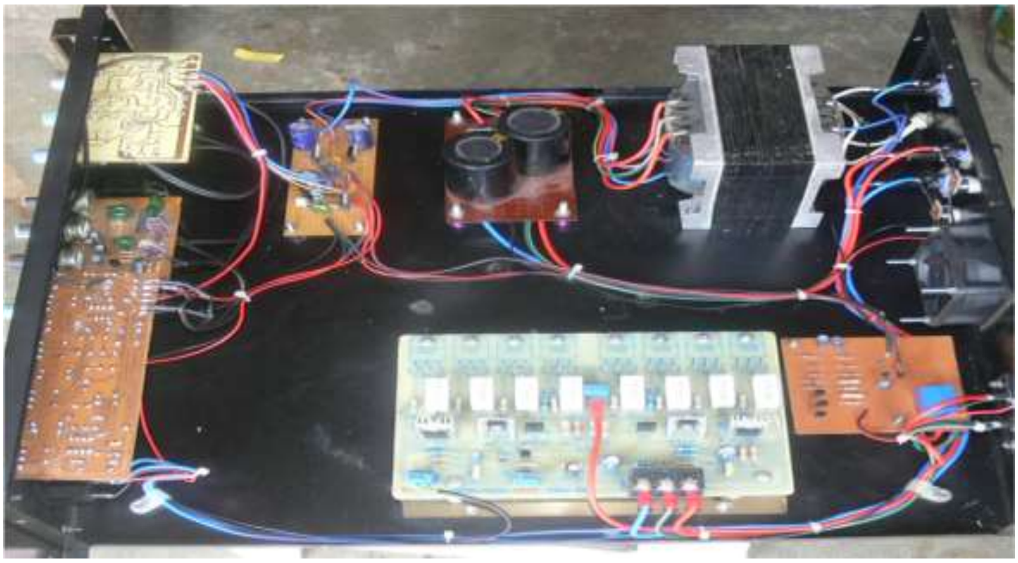

Figure 2.2. Overall Assembly of Audio Power Amplifier

3. RESULTS :

This section will explain the results of the system in two parts: simulation results and testing results.

3.1 Simulation Results

The input signal was fed to power amplifier by using signal generator. In this case, standard input audio signal of 1k Hz was used. Fig.3.1 shows the comparison of overall input and output waveforms. From these results, the overall voltage gain of 29.28 dB was achieved.

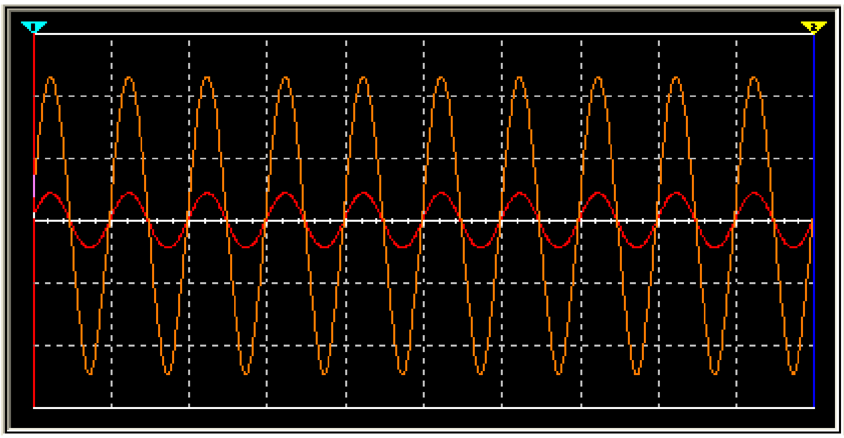

Figure 3.1. Comparison of Overall Input and Output

3.2 Testing Results

3.2.1. Functionality Testing

After constructing the overall system, the main part of audio power amplifier was tested firstly.

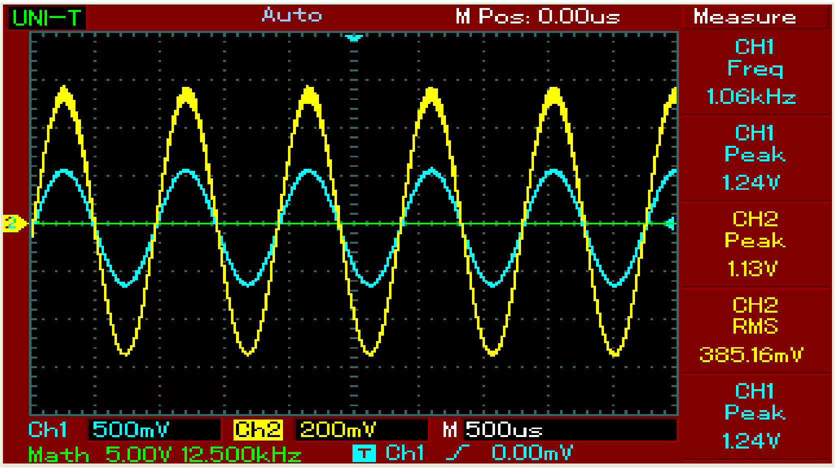

Figure 3.2. Experimental Result of Input Stage

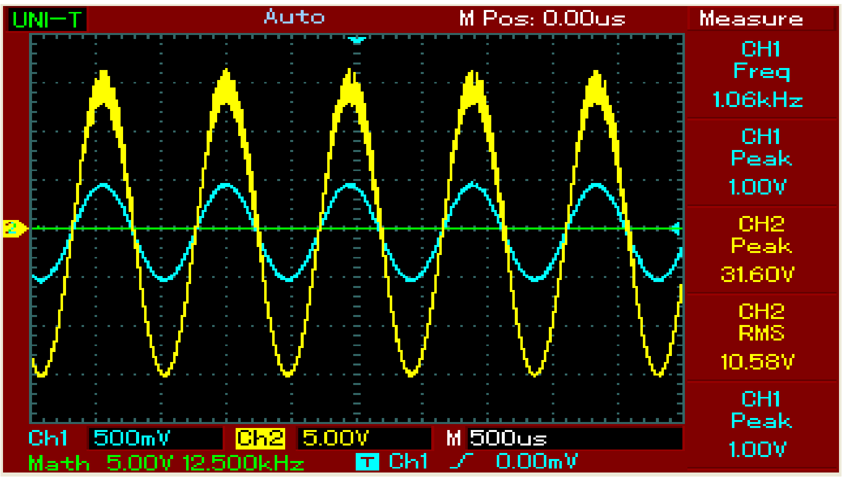

Figure 3.3. Experimental Result of Voltage Amplifier Stage

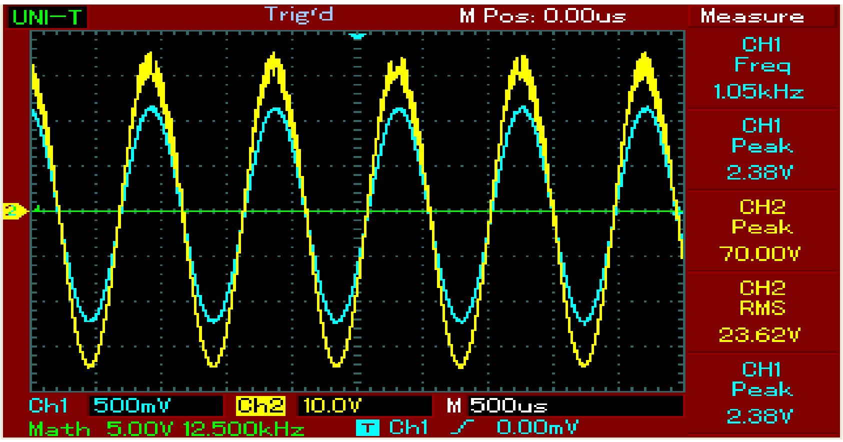

Figure 3.4. Experimental Result of Output Stage

Fig.3.5 shows the overall testing of audio power amplifier. From the testing result, the overall voltage gain of 28dB was achieved.

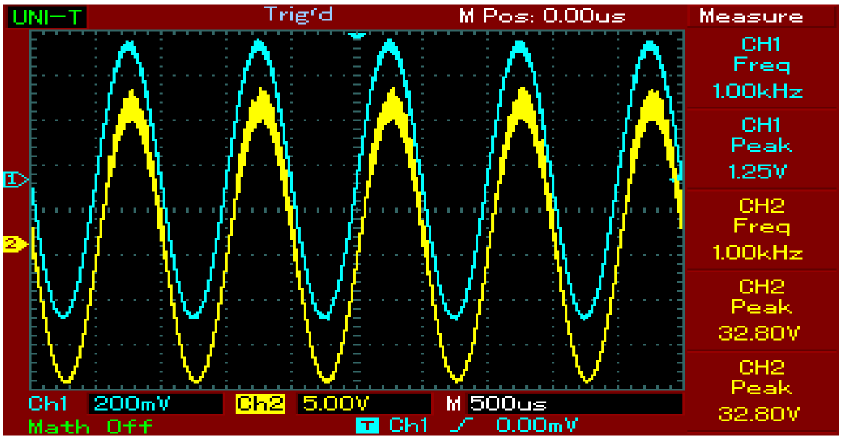

Figure 3.5. Overall Output Waveform of Audio Power Amplifier

3.2.2. Efficiency Testing

Efficiency testing was recorded at 10 frequencies in the audio frequency band: 20Hz, 50Hz, 100Hz, 500Hz, 1 kHz, 2 kHz, 5 kHz, 10 kHz, 15 kHz and 20 kHz. Fig.3.6 shows the plot of different efficiency at various input frequencies.

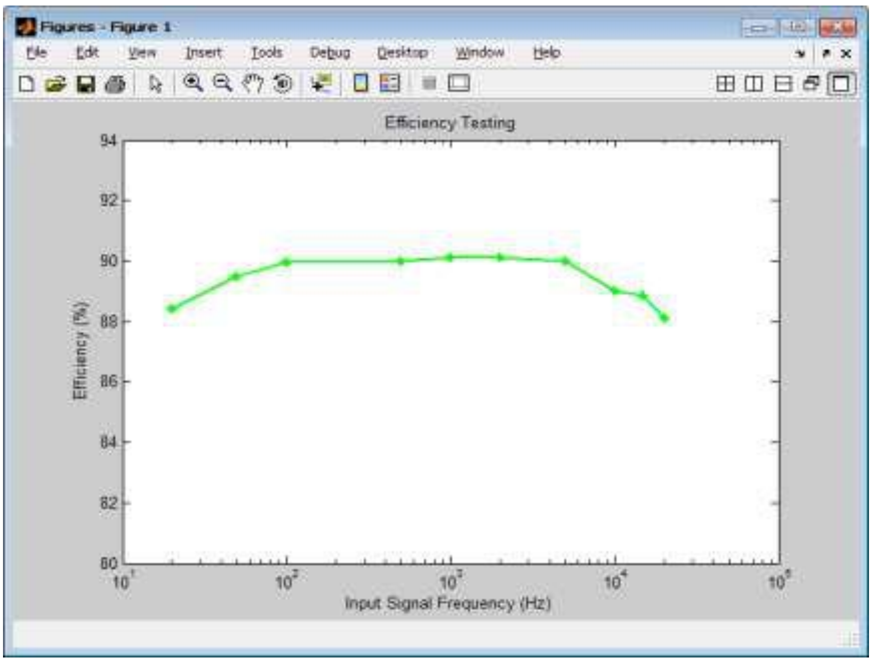

Figure 3.6. The Plot of Different Efficiency at Various Input Frequencies

4. CONCLUSION:

The DC-coupled audio power amplifier based on OCL system was designed, constructed and tested. Both discrete type and IC type components were used in this system. Each part of the overall typical audio power amplifier was simulated and constructed. After constructing the overall system, the output power of 200W was achieved from the experimental results. From the design calculations, the speaker power of 50W was achieved. This was proved by using digital sound level meter. From the calculation, simulation and testing results, the overall voltage gain of about 30dB was obtained.

5. RECOMMENDATION:

This system was high efficiency and can be workable successfully. Sound quality performance was acceptable by using this system. This audio power amplifier can drive four 4Ω speakers. It is suitable not only for lecture room but also for other ceremonies or meetings. Audio power amplifier of this design can be extended two or four channel per amplifier unit, usually for stereo or surround sound system. The protection against DC faults can be extended. A DC-coupled amplifier requires an output relay for dependable speaker protection. It can be used with other amplifier modules and commercial stereo amplifiers and protects the loudspeakers in the event of a catastrophic amplifier failure. The module also mutes the loudspeakers at switch-on and switch-off to prevent those scary thumps.

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