Electronic Workshop 2: Audio Amplifier

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Abstract

We aim to build an Audio Amplifier that takes in an input sound signal of bandwidth of frequency of voice and amplifies it, ideally without noise. To do this, we target to have minimal use of Integrated Circuits. By building this, we hope to gain a working understanding of the design tricks, errors, and corrections.

1. Introduction and Theory

An audio power amplifier (or power amp) is an electronic amplifier that reproduces low-power electronic audio signals such as the signal from radio receiver or electric guitar pickup at a level that is strong enough for driving (or powering) loudspeakers or headphones. It is the final electronic stage in a typical audio playback chain before the signal is sent to the loudspeakers and speaker enclosures.

We intended to make an audio amplifier that would take a sound signal of a song played from a mobile phone as input and produce an amplified version of the very same song without noise.

Circuit Design is one of the most important take aways of this project. We learnt how to select circuit elements and their values, what effects to consider and which factors to neglect or compromise on.

Our circuit consisted of the following main sub sections:-

- Input/Micrphone
- Gain Stage
- Frequency Filter

- Power Amplifier
- Output/Speaker

2. Input Stage

This stage consists of a transducer, in the case of an audio amplifier it is a microphone, which is biased properly to ensure a clear input signal is given to the circuit. After biasing, the input recieved is observed to be 20mV peak to peak.

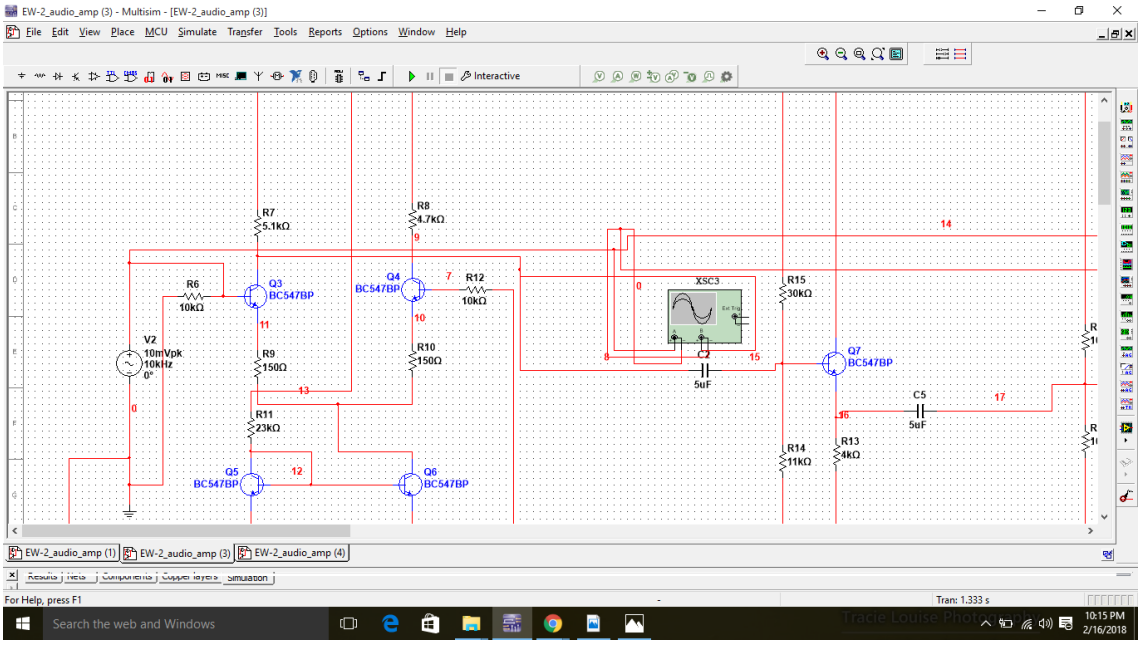
3. Gain Stage

This is the most crucial stage of the amplifier. It is this stage that the voltage gain and the SNR (Signal to Noise Ratio) of the entire circuit is decided. The input signal to this stage is 20mV peak to peak. This stage consists of several sub-sections:-

- Pre-Amplification
- Circuit Buffer
- BJT Gain

3.1. Pre-amplification Stage

A preamplifier is an electronic amplifier that converts a weak electrical signal into an output signal strong enough to be noise-tolerant and strong enough for further processing, or for sending to a power amplifier and a loudspeaker.
In our design, we have used a differential amplifier for this stage. The pre-amp stage is placed closed to the source as it reduces noise. This is what a differential amplifier does. (It has a high CMRR and hence reduces noise.) The gain of our pre-amplification stage is about 10. Further it also has a high input impedence which ensure the input signal stength is not lost. A current mirror configuration is applied to the differential amplifier as we desire to take a single output and not two outputs. The components used in this stage is a differential amplifier.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R10 150Ω
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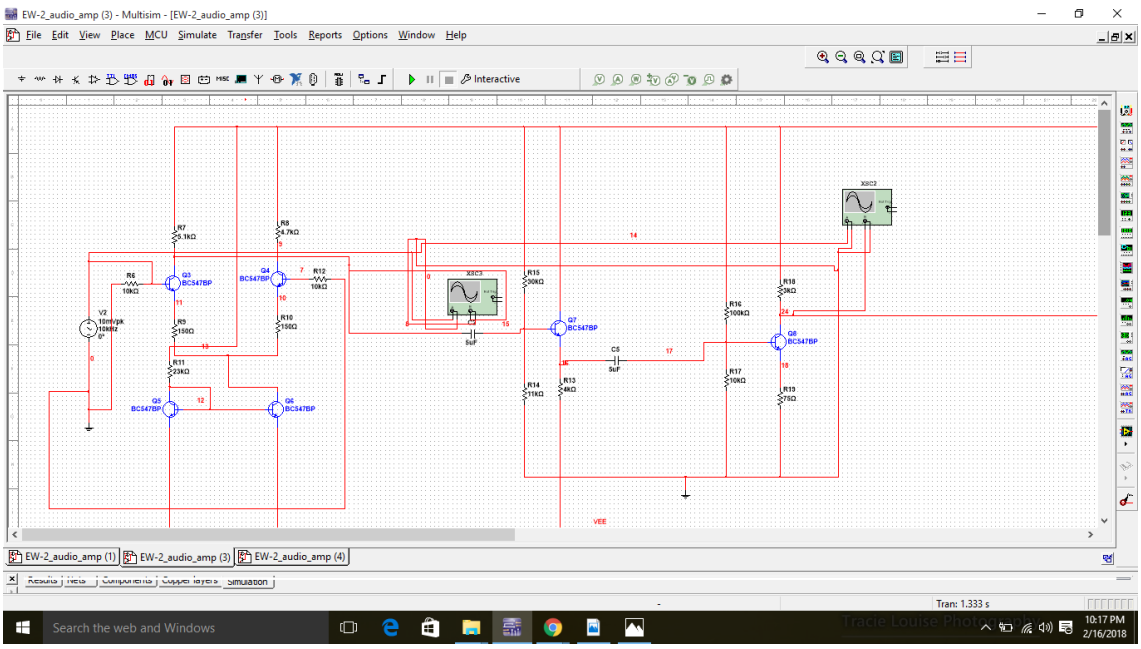
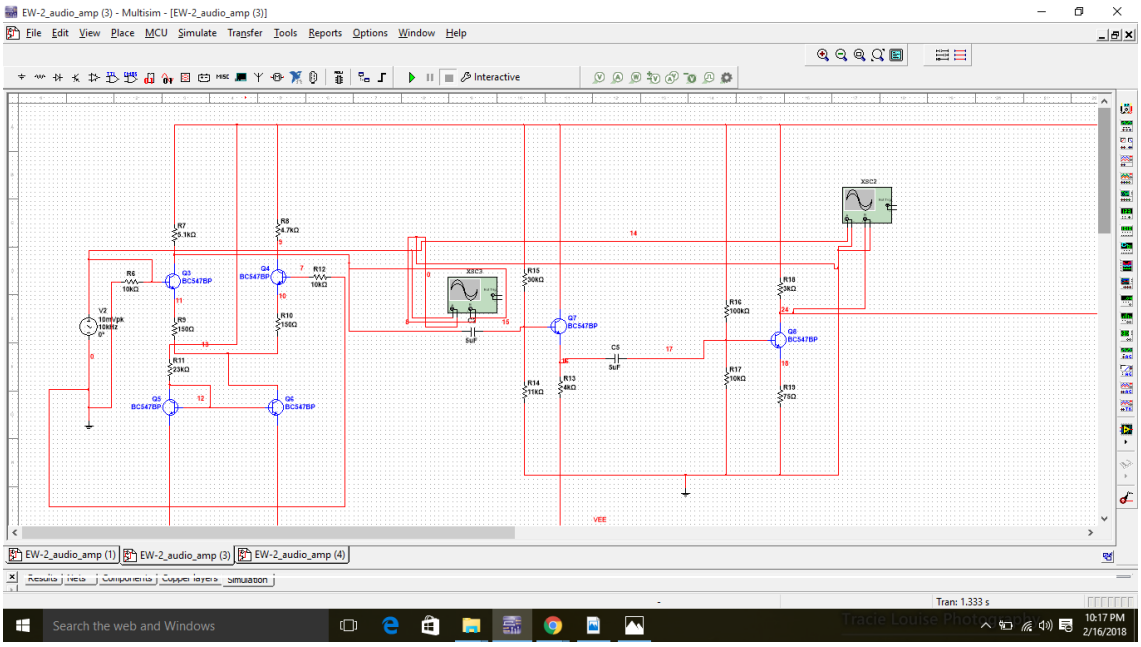
3.2. Circuit Buffer

A buffer amplifier (sometimes simply called a buffer) is one that provides electrical impedance transformation from one circuit to another, with the aim of preventing the signal source from being affected by whatever currents (or voltages, for a current buffer) that the load may produce. It prevents any form of attenuation and amplification. Draws very little current and doesn't disturb the main circuit. the output voltage follows the input voltage and this circuit has high input impedance. The CE part has low impedance and draws large amount of current causing power loss which is why high input impedance is needed. This helps in the transfer using isolation circuits. The components used in this stage are a BJT and resistors.



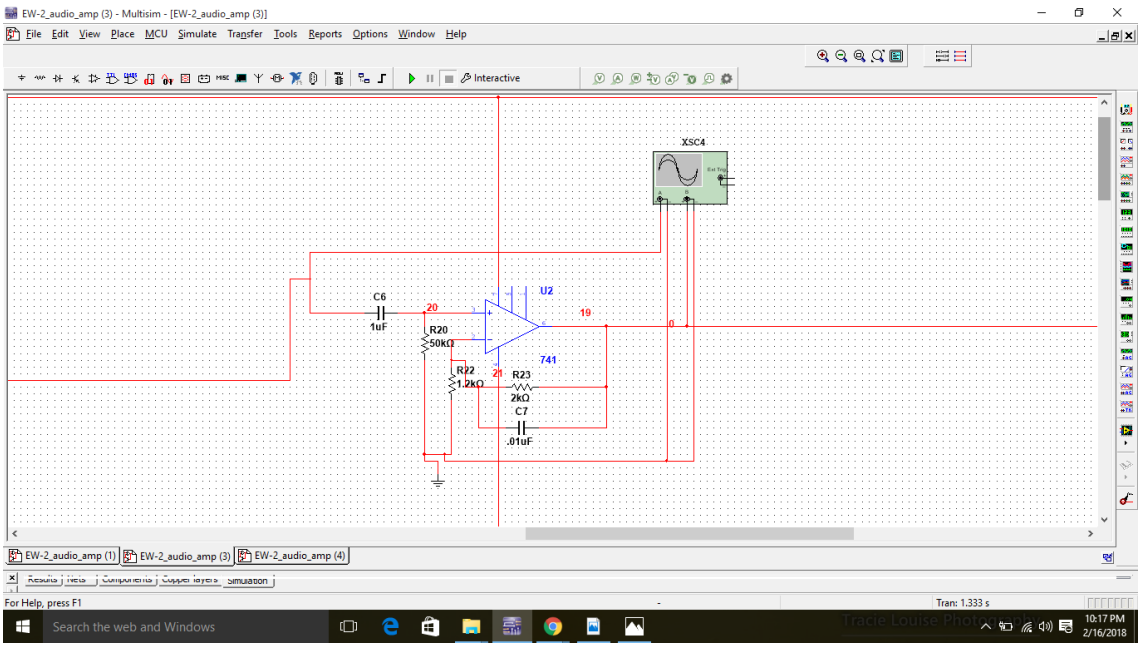
3.3. BJT Gain Stage

After a small voltage amplification in the pre-amplifier, we pass the signal through a Common Emitter BJT amplifier to increase voltage to 5V peak to peak. To make the pre amp stage compatible with this stage by impedance matching, we use a buffer circuit. At the end of the gain stage, the voltage of the signal is about 5V peak to peak, gain being about 250. The components used in this stage is a Common Emitter Amplifier.



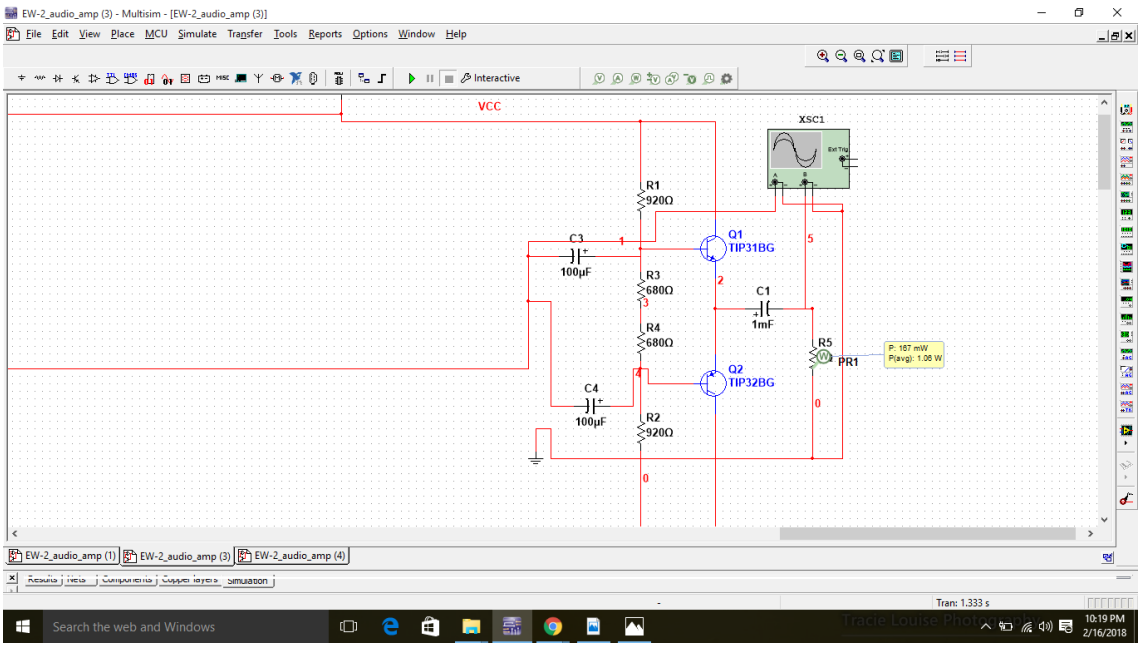
4. Frequency Filter Stage

A band-pass filter (also bandpass filter, BPF) is a device that passes frequencies within a certain range and rejects (attenuates) frequencies outside that range. We use a band pass filter to ensure that only frequencies of speech signals are allowed through and any unwanted noise that is amplified is rejected. In our design, we have used an active filter consisting of an op amp (IC 741), and a combination of a low pass and a high pass filter to achieve band pass frequency. As the speaker of the Output Stage works on 10V peak to peak voltage, hence we also need to provide a gain of 2 which is integrated in this part as well. The components used in this stage are op amp IC 741 along with resistors and capacitors.



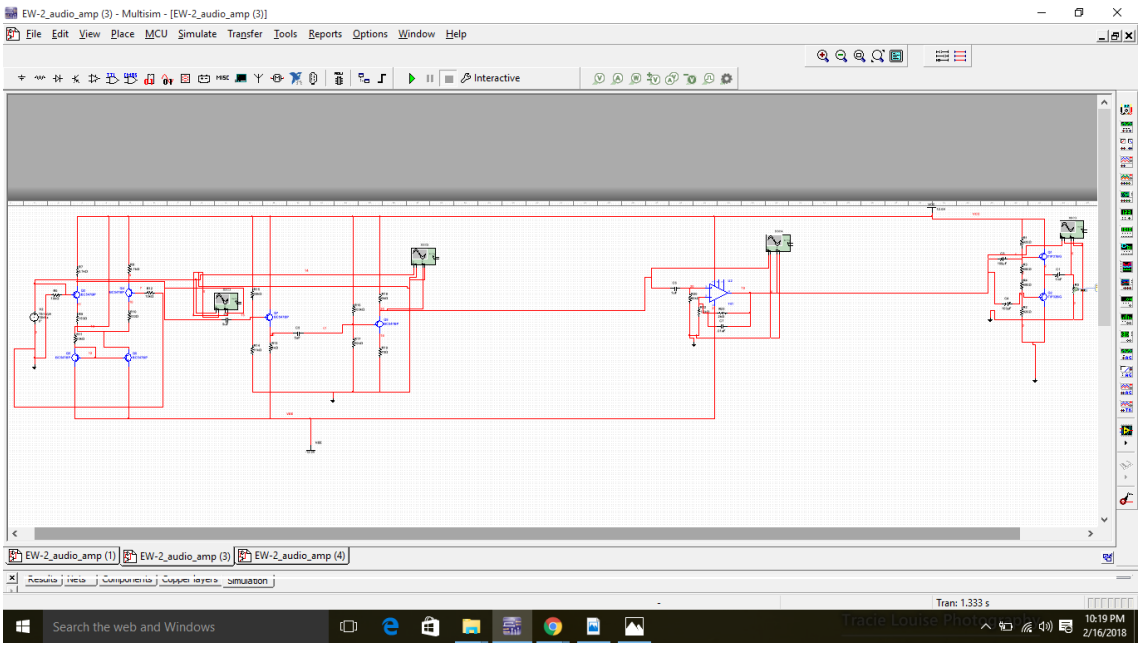
5. Power Amplification Stage

Power amplification stage increases the current of the signal while maintaining the voltage constant. The current and thereby power is increased to enable the speaker to produce an output. The power amp we have used is of AB type. The Average Power at the end of this stage is about 1W with voltage being 10V peak to peak. The components used in this stage are npn and pnp power transistors along with power resistors and capacitors.



6. Full Audio Amplifier Circuit

The final circuit turns out to be:-



7. Output Observations

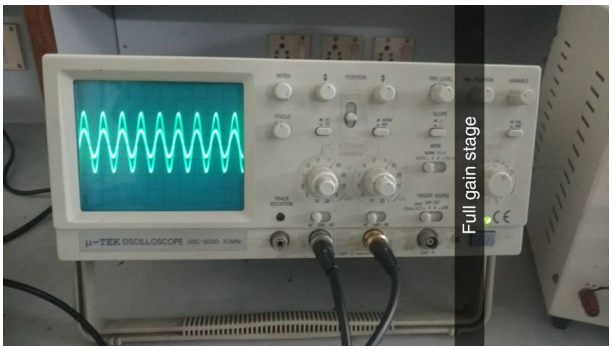
At the end of building the circuit of each stage, the voltage (or respective circuit paramters) was measured using devices like multimeters, CROs etc. The following table illustrates the voltage paramter change throughout the entire circuit.

	Input	Output	Gain
Input Stage	-	10mV	-
Pre-Amplifier	10mV	100mV	10
BJT Gain	100mV	2.5V	250
Filter	2.5V	5V	2
Power Amplifier	5V	5V	1

Table 1: Input and Output voltage magnitudes.

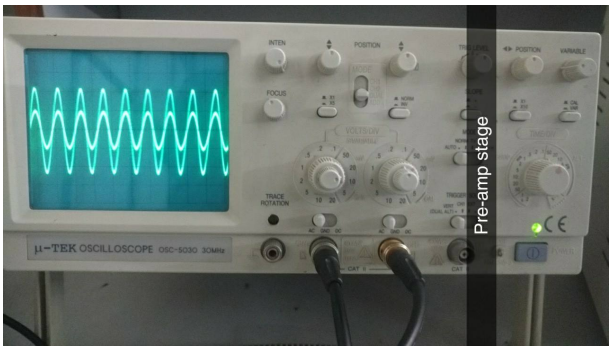
8. Pre-Amplification

At the end of this stage we get a signal of magnitude 10 times the input.



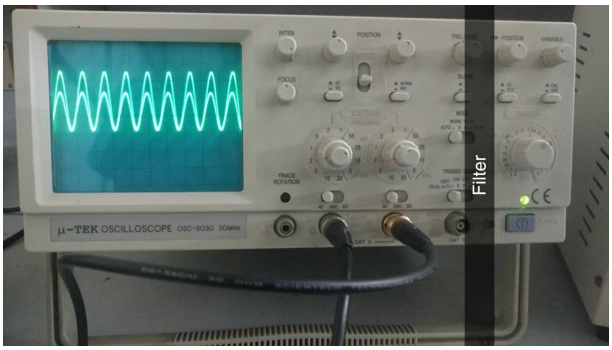
9. Gain Stage

At the end of this stage we get a signal of magnitude 25 times the input.



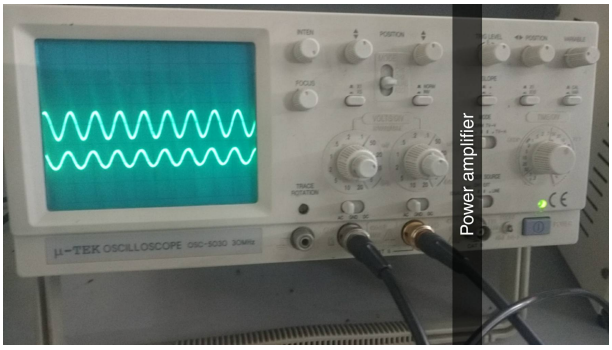
10. Filter

At the end of this stage, we put a restriction of the frequencies while also getting a gain of 2.



11. Power Amplification

The output power averages at 1W with the overall voltage gain being 500.



12. Frequency Response

The frequencies that the audio amplifier allows at the end is in the range 80-6000.