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Constructing a model of an amplifier

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1 Introduction

We can easily increase the volume of our television to make the sound more audible. But how does the volume increase by a click of our remote? It happens due to an amplifier. What is an amplifier and how does it work? With these intriguing questions in mind, I started to explore how an amplifier functions, and I constructed a model of an amplifier.

2 The function of an amplifier

An amplifier increases the volume amplitude of the electrical signal of the sound wave. Amplitude is the distance between the maximum and middle values of any wave.

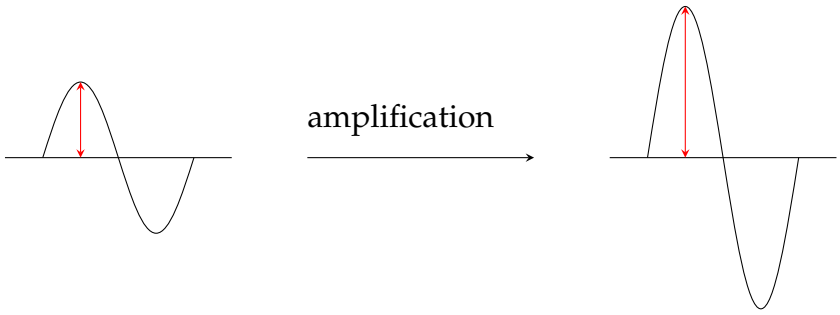

Figure 1: Amplification

Vacuum tubes were initially used for amplification, but nowadays we use transistors. The basic fundamentals of amplification however remain the same.

[1]Aadit Jain is a High-School Junior interested in creating models to depict real-life phenomena.

3 How an amplifier works

A basic amplifier (transistor or vacuum tube) consists of a *gate*, a *cathode* and an *anode*. The input sound-wave, in the form of an electrical signal, is attached to the gate. An electrical signal with a high current, much higher than the input sound wave, passes from the anode to the cathode. To better understand an amplifier, let's compare it to a tap-water system, where water is equivalent to an electric signal:

tap		amplifier
our hand controlling the tap flow	$\longleftrightarrow$	input sound wave at gate
flow of water entering tap	$\longleftrightarrow$	current at anode
flow of water leaving tap	$\longleftrightarrow$	current at cathode

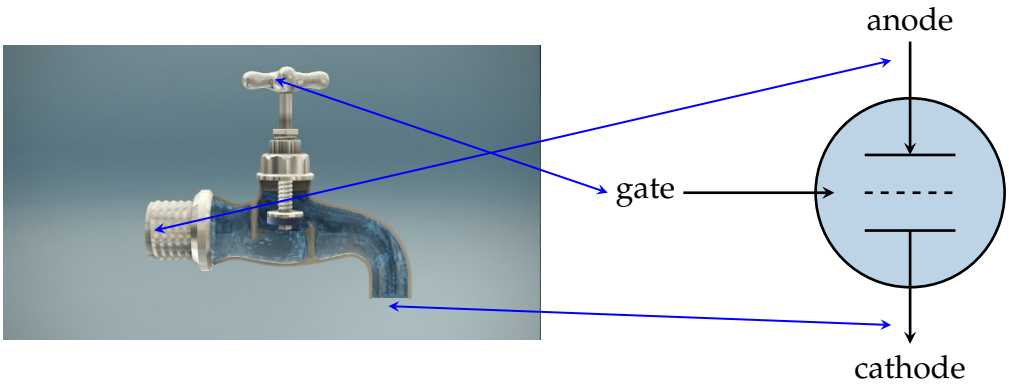

Figure 2: Tap equivalent model. Tap adapted from [1].

As we apply more force by our hand to the tap, the tap opens more, and more water flows through the pipe. Similarly, as the current of the sound wave increases, the gate opens more, and more electrical signal (meaning higher current) passes from anode to cathode. For illustration purposes, let's say that the maximum current of the input sound-wave is 10mA and that the maximum current of the electrical signal from anode to cathode can be 100mA. When the current of the sound wave is 0mA, the gate won't open and no current will pass. When the current of the sound wave is 5mA, $\frac{5}{10}$, or $\frac{1}{2}$, of the gate will open and 50mA of current will pass. When the current of the sound wave is 7mA, proportionately $\frac{7}{10}$ of the gate will open and 70mA of current will pass.

Hence, the current of the input sound wave proportionally affects the amount of gate that opens and influences the current of the electrical signal passing from anode to cathode. This relationship enables the electrical signal to have a similar shape as the sound wave but with a higher amplitude.

The important thing to note is that an amplifier does not directly amplify the electric signal of sound wave. Specifically, the amplifier does not increase the amplitude of the input sound wave itself: the input wave is unchanged. Rather, it creates a new electrical signal with a same shape but a higher amplitude.

4 Construction of the model

Based on the workings of an amplifier, I created a model of it. The model consists of an electrical circuit with various $1k\Omega$ resistors such that they can be attached in parallel. One end of all resistors is soldered together, whereas their other end is left floating, to eventually be connected by a sliding metal strip. The circuit is powered by a 9V battery.

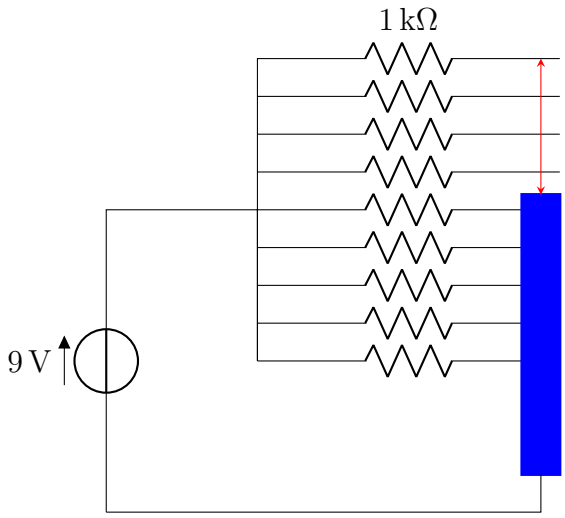

Figure 3: Model of a transistor using parallel circuits

The big movable metal plate acts as the gate. That plate is moved by hand to touch a certain number of resistors. Current is not able to pass through the remaining resistors as they are not touching the plate. Since this is a parallel circuit, current passing through each individual resistor adds up to make the total current. For example, if the plate touches only 1 resistor strip, then the current would be $9\text{V}/1k\Omega = 9\text{mA}$ by Ohm's Law: $I = V/R$. If it touches 2 resistor strips, then the current would be $2 \times 2\text{mA} = 18\text{mA}$. Therefore, if the plate touches 20 resistors, then the current would proportionately be $20 \times 9\text{mA} = 180\text{mA}$. This shows how an amplifier works on the basis of mathematical proportion. We use the gate to control the flow of a higher current path, thereby mimicking the shape of input signal at gate, but with a higher amplitude.

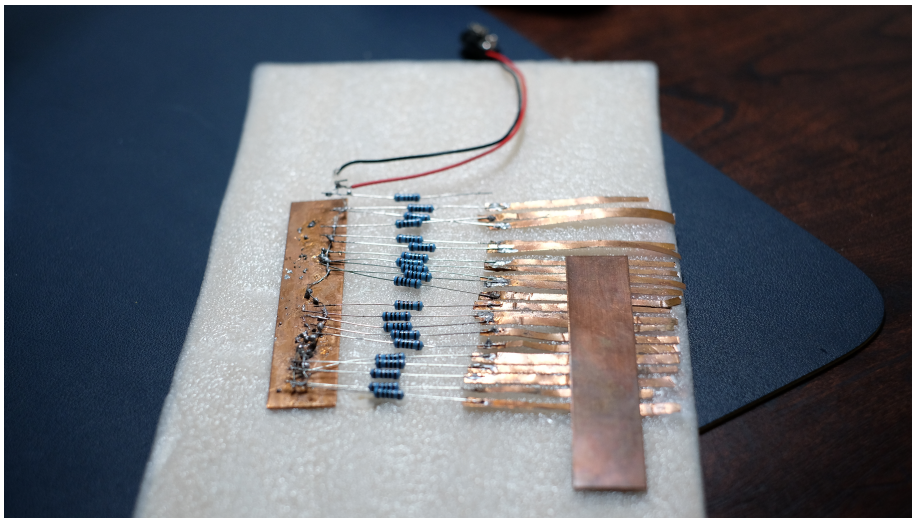

Figure 4: Actual model

5 Conclusion

This project depicts an amplifier by utilizing the simple concept of a parallel circuit to model a more complicated device, the amplifier!

Acknowledgements

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References

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