

**EE2073 Project Report**

**Automatic Volume Control**

**for Audio Amplifier System**

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Table of Contents

[Introduction 3](#_Toc164458936)

[Subsystems 3](#_Toc164458937)

[Voltage Controlled Amplifier System 3](#_Toc164458938)

[Gain Sensitivity 3](#_Toc164458939)

[Power Amplifier System 4](#_Toc164458940)

[Gain Bandwidth Product (GBWP) of Op-Amp 4](#_Toc164458941)

[Volume Unit Meter System 4](#_Toc164458942)

[Rectifier and Peak Detect and Hold Circuit 4](#_Toc164458943)

[Function of VU meter 4](#_Toc164458944)

[Offset in Vin 4](#_Toc164458945)

[Automatic Volume Control System 5](#_Toc164458946)

[Relationship of Vaudio and System Gain 5](#_Toc164458947)

[Step-up-down controller 5](#_Toc164458948)

[RepeatTimer Class 5](#_Toc164458949)

[Challenges Faced 6](#_Toc164458950)

[Wrong connections 6](#_Toc164458951)

[Noise 6](#_Toc164458952)

[Conclusion 6](#_Toc164458953)

[Appendix 7](#_Toc164458954)

[Reference 11](#_Toc164458955)

# Introduction

The objective of this project is to create an Automatic Volume Control for Audio Amplifier System to understand the process of designing and integrating different circuits together. This project is built with various Integrated Circuit (IC) Chips, STM32 microcontroller supplemented with MicroPython firmware and a custom-designed board, VScope, and Python.

With the given input signal, the aim is to automatically adjust the output signal to a desired volume using feedback loop which detect the current volume and change the volume gain accordingly using step-up-down method. Despite having experience in creating an Audio Amplifier System in the past, the addition of the automatic volume control and microcontroller added complexity. While the overall process was smooth, it did come with challenges along the way, and this is due to the complexness and lack proficiency to rectify the obstacles. In the end, it was a rewarding experience as this has given me the confidence for the upcoming projects to come. Schematic diagram of subsystems was taken from Lab Manual PDF file (School of Electrical and Electronic Engineering, n.d.). Do note that the figures referred can be found in [*Appendix*](#_Appendix).

# Subsystems

The system is split into 4 circuits: Voltage Controlled Amplifier (VCA) Subsystem, Power Amplifier (PA) Subsystem, Volume Unit (VU) Meter Subsystem and Automatic Volume Control Feedback Subsystem. Each provide crucial functionality to the whole system.

## Voltage Controlled Amplifier System

The VCA system function is to change the amplitude of a signal in response to a controlled voltage applied to its input. This subsystem uses 2180C and OP275 IC chips.

Gain Sensitivity

From the measured results in *Figure 2* and *Table 1*, the controlled voltage (Vc) is inversely proportional to the gain as when controlled voltage is small, the gain of the amplifier becomes bigger. From the result, the gain sensitivity = ~ -9mV/dB, which is larger in magnitude when compared to the theoretical gain sensitivity of -6mV/dB. When having high signal amplitude with high VCA gain, the results will lead to saturation which in theory result in Vout = 13.5V in magnitude.

## Power Amplifier System

The power amplifier system purpose is to amplify the gain and power of the output to drive the speaker. This system uses the LM380N Op-Amp IC Chip.

Gain Bandwidth Product (GBWP) of Op-Amp

From *Figure 4*,the gain starts to drop more sharply after 2kHz, this can be backed up from the LM380N Op-Amp has a Gain Bandwidth Product of 100kHz and a fix voltage gain of 50 or 34dB (*LM380N Texas Instruments - Datasheet PDF & Technical Specs*, n.d.). When we calculate the cut off frequency from the GBWP, it results in 2kHz. This can also be observed from our measured values.

## Volume Unit Meter System

Volume Unit Meter System is used to measure the output signal from the PA system and convert it to a constant voltage by making use of diodes and capacitors to make a rectifier. This system uses the CA3140 IC chip together with IN914 diodes and 10u Capacitor.

Rectifier and Peak Detect and Hold Circuit

The Op-Amp acts as a half-wave rectifier, in addition with a diode, it becomes a full wave rectifier. Lastly, when adding an additional diode with a capacitor, it detects and hold the peak voltage levels of the output which then result in Vout3.

Gain Characteristic and Function of VU meter

From *Figure 7*, The magnitude of the average gain of Vout2 from measured results is around 0.702 which is very close to the theoretical gain value of 0.7. Also, the plot of Vout3 RMS vs Vin produces a linear best fit line which is close to the measured results. This concludes that the Vout3 follows Vin linearly very closely. Therefore, the function of the VU meter can be met.

Offset in Vin

With an offset in Vin, Vout3 will produce an inaccurate reading as the offset will also be amplified. Too high of an offset might cause damage to the Op-Amp. Another factor to consider is the magnitude of the input, having a magnitude that is too high will cause the Op-Amp to saturate to 13.5V. This results in distortion and the VU meter will fail to function as desired.

## Automatic Volume Control System

Before implementing the Automatic Volume Control System, integrating all first three subsystem was done to test and ensure that the three subsystems can work as desired.

Relationship of Vaudio and System Gain

From *Figure 8*, when we measure and visualise the relationship between the controlled voltage and the gain of the Vaudio, an almost linear relationship can be observed. This concludes that the three subsystems are working as desired. It can be recalled that a lower controlled voltage will result in a higher gain which can be observed too.

Step-up-down Controller

With the addition of the automatic volume control, a step-up-down controller is implemented to control the increment or decrement of the controlled voltage. Adjusting the controller to have smaller step would result in a smoother change in volume. On the other hand, a higher step might cause distortion, however this would allow the user to get to the desired volume quicker.

RepeatTimer Class

Additionally, the time interval to call the “RepeatTimer” class is an important function of the Automatic Volume Control Subsystem. The class is to allow the microcontroller to read the current volume of the system to it can be feedback into the system to readjust. Calling the class with shorter time interval would allow the volume to be adjusted faster. From *Figure 9,* a flaw in this would be the ‘Try’ method on the ‘\_run’ function. It test on whether the function is able to complete before setting the interval for the function. A potential issue would be the complexity or the time delay of the given function. Such factors would cause this class to be unreliable to follow the set interval.

# Challenges Faced

This lab gave me enriching challenges that taught me to be aware of my workmanship. Another key lesson I learnt was staying calm as I was working on projects as mistakes will happen. Additionally, being unfamiliar with designing and troubleshooting an unfamiliar system caused doubts in myself.

## Wrong connections

Human error is something that is expected in everything do. Some error in connections impaired the progress and troubleshooting was required. Wrong connections were also caused by being careless in the reading the schematic diagram. All these would cause frustrations which was not helping as it made me more careless. This would hopefully remind me to be more careful in my connections for my future projects.

## Noise

Noise was also expected as it is not in ideal condition. Mitigating noise was key in getting accurate results to allow us to understand the circuit. To reduce noise, I reduced the number of wires used in the circuit. Additionally, isolating the output GND and input GND of the PA subsystem was important due to the high current in the output.

# Conclusion

This project has been helpful in educating the importance of designing process. It is important to break down the overall circuit into key parts to ensure that all parts of the circuit are functioning as desired before integrating them together. This project has also taught me that we must be patience and fall back to the basics whenever we are stuck. We also must understand that we have our own limits that cause us to make simple and obvious mistakes. To conclude, I have successfully completed this project and learnt the key concept along the way. This have been enriching for my future projects and I appreciate the efforts done by the Professors, Teaching Assistants and Staffs in making this project for the students.

# Appendix

A diagram of a circuit

Description automatically generated

Figure 1 VCA schematic provided

A graph showing the difference between a number of points

Description automatically generated with medium confidence

Figure 2 Controlled Voltage (Vc) vs Gain



Table 1 Measured and Calculated Results

A diagram of a circuit

Description automatically generated

Figure 3 PA schematic provided



Table 2 Measured Results

A graph with colored lines

Description automatically generated

Figure 4 Plotted Graph from measured results

A circuit diagram of a device

Description automatically generated

Figure 5 VU Meter schematic provided

A graph with a red and blue line

Description automatically generated

Figure 6 Vout1 - Vout2 - Vout3

A table with numbers and letters

Description automatically generated

Table 3 Measured Results

A graph showing a number of different colored lines

Description automatically generated

Figure 7 Vout2 & Vout3 Gain vs Vin



Table 4 Measured Result of Lab 8

A graph with red dots

Description automatically generated

Figure 8 Controlled Voltage vs Gain of V-audio

A computer screen shot of a program

Description automatically generated

Figure 9 RepeatTimer Class

A computer screen shot of text

Description automatically generated

Figure 10 step-up-down controller code

# Reference

*LM380N Texas Instruments—Datasheet PDF & Technical Specs*. (n.d.). Retrieved 19 April 2024, from <https://www.allaboutcircuits.com/electronic-components/datasheet/LM380N--Texas-Instruments/>

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