

**College of Engineering and Applied Science  
CET Senior Design**

Submitted to: Professor Michael Haas

**Sound Equalizer for Home Entertainment**

**Final Report**  
Daniel Picard

June 7<sup>th</sup>, 2011

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Middletown, OH 45042

June 7, 2011

Professor Michael Haas  
University of Cincinnati  
College of Engineering & Applied Science  
2220 Victory Parkway  
Cincinnati, OH 45206

Dear Professor Michael Haas:

Attached is my final report for the “Sound Equalizer for Home Entertainment” as requested by the CEAS faculty.

This final report gives details to the work and completion of my project. It gives details into the problem, solution and methodology used for this project. I also outlined the general issues encountered with the project and possible means for improvement. Overall this will show the how this project was conceived and implemented.

During the project I consulted with many professors, and professionals for help. These included Professor Elvin Stepp, and the members of the AudioDIY forum. These, along with many students, helped me to build a solution to the problem. Thank you for your time as my advisor and your time and effort in reviewing the following report. If you have any questions or concerns please feel free to contact me at any time.

Sincerely,

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# Sound Equalizer for Home Entertainment

A thesis submitted to the  
Faculty of the Computer Engineering Technology Program  
of the University of Cincinnati  
in partial fulfillment of the  
requirements for the degree of

Bachelor of Science

in Computer Engineering Technology  
at the College of Engineering & Applied Science

by

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May 2011

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## **ACKNOWLEDGEMENTS**

- Rachel Stadler, my loving fiancée who supported me through all the long nights and headaches, without whom I would be eternally lost.
- Professor Michael Haas, who guided me throughout the senior design process and who gave me the original idea for my project.
- Professor Elvin Stepp, who set me on the right path for my project.
- Digikey, and Radioshack who provided quality parts in an amazing shipping time.
- AudioDIY, for their constructive criticism, constant help, and endless support.
- Google, the finder of all things on the internet.

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## **ABSTRACT**

The Sound Equalizer for Home Entertainment is a prototype design to help control the large changes in audio that is caused by different standards compliance between audio devices. These large changes from device to device are at the minimum an annoyance, to at worst a large costly mistake. The sound equalizer helps to fix and even eliminate this issue. The device also requires no external power to operate so it can be placed in difficult area's without the need to find an extra plug to give it power, which can eliminate a lot of frustration. It can also be used in several places in your audio system to help keep a nice smooth audio, whether you are an audio aficionado or just want to a nice equal audio level.

## INTRODUCTION

The report outlines the process involved in the creation of the Sound Equalizer for Home Entertainment.

The Sound Equalizer for Home Entertainment is a system to normalize the audio input from several different input devices. This allows for a home entertainment system to be utilized properly with different input devices. This system is meant for people to enjoy their audio experience because of the variable audio input from devices such as VCR's, DVD players, and gaming consoles. These systems all have a different default audio output which causes the audio on the TV to vary from blaring loud to whisper quiet.

The proposed system will contain both a hardware component and software component. The objective of the hardware component will be to primarily serve as audio input capturing and video pass-through. The secondary objective for the hardware portion is to adjust the audio output once calculations have been made for the adjustment. The software portion of this device will be to monitor the audio input and calculate the amount of adjustment needed to achieve the correct audio level for the system.

As an avid movie enthusiast and someone who has had to deal with this issue for many years, and an up and coming computer engineer with experience developing both hardware and software, I feel that I have the qualifications for the design and development of such a device.

## PROBLEM

Different equipment will output various audio levels depending on the various input devices. This wide variety of audio levels causes headaches as it is a hassle to constantly switch between all of the various general audio levels from each of the devices. These changes, though they seem minor, can build up to be a very large hassle.

Not only can this inconvenience become a hassle, it can also become expensive hobby. If upon switching audio devices a speaker is blown out, the replacement could be extremely costly depending upon the system. These blowouts can occur when switching between devices that have very large audio level differences. A computer generally has a lower audio output level, whereas a guitar generally has a higher audio output level. If the sound was at the perfect level on the computer, and then the user switched to a guitar, it could blow out the speakers and become a pricy mistake.

Damage to physical equipment is just one kind of damage that can occur from large changes in audio levels between devices, damages to hearing can also be risky to a person over the long term. Constant changes to audio levels, and blaring audio, is a growing health concern. This hearing loss seems insignificant, but over a lifetime can cost a great deal of money in hearing aids. In all these constant changes can become a financial burden over a lifetime.

## PROBLEM CONTINUED

For this problem it was originally decided that the device would need to accomplish these points:

1. Remove DC offset
2. Keep dynamics of the signal
3. Have low distortion

Optional Requirements:

1. Fully electronic circuit
2. No need for external power

## SOLUTION

I believe that the simplest solution to this would be to use the Sound Equalizer for Home Entertainment. This idea would be much simpler, and cheaper, than any other known equipment. A similar piece of equipment would be a sound board. These products are pricy and very complicated, requiring training and understanding to use effectively. Unfortunately, these products are also not automated, the user would then have to manually adjust the sound each time which really does nothing to fix this problem. My solution would eliminate the need for such pricy equipment and human intervention, as well as the training necessary to operate such a device. This idea would allow for a very quick change in audio levels and a nearly perfectly equal audio level for the user so that manual adjustments wouldn't be needed for every equipment change, if at all.

Figures 1 and Figure 2 below show the original and updated designs for this project respectively. This design was based off of an original design of an automatic gain controller used for cassette tapes, or radio applications. The original purpose of these devices was to boost audio gain to a fixed level for the user to listen to, even with poor signals. I have modified the original design by modifying the gains and using the transistor in a slightly different capacity. Originally the transistor was used to boost the gain of the circuit from an infinite input impedance to 150ohms. I have decided to switch that number as I do not necessarily need to boost the signal to that degree. The rest of the circuit strips the signal of its DC offset and makes a final amplification of the signal so that it is roughly the same level as the original signal with only a small shift in phase and a distortion level.

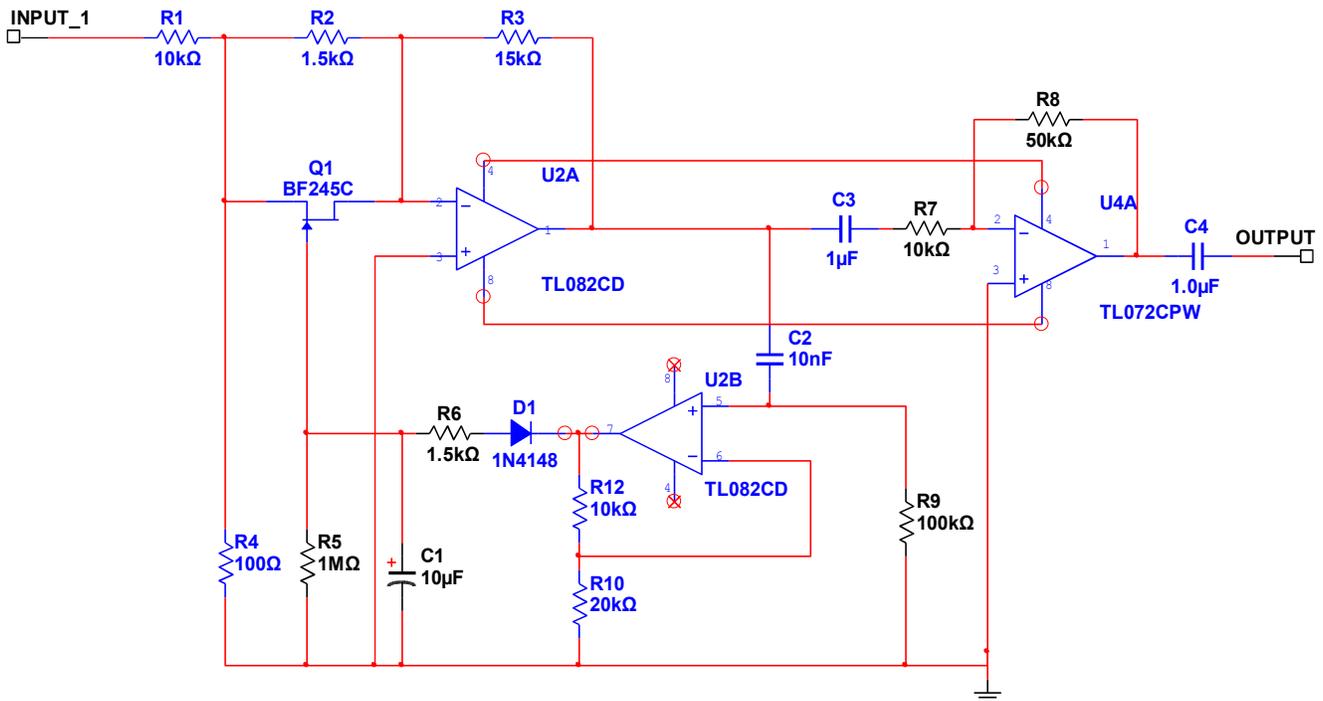


Figure 1: the original design of the project as based off of an automatic gain controller

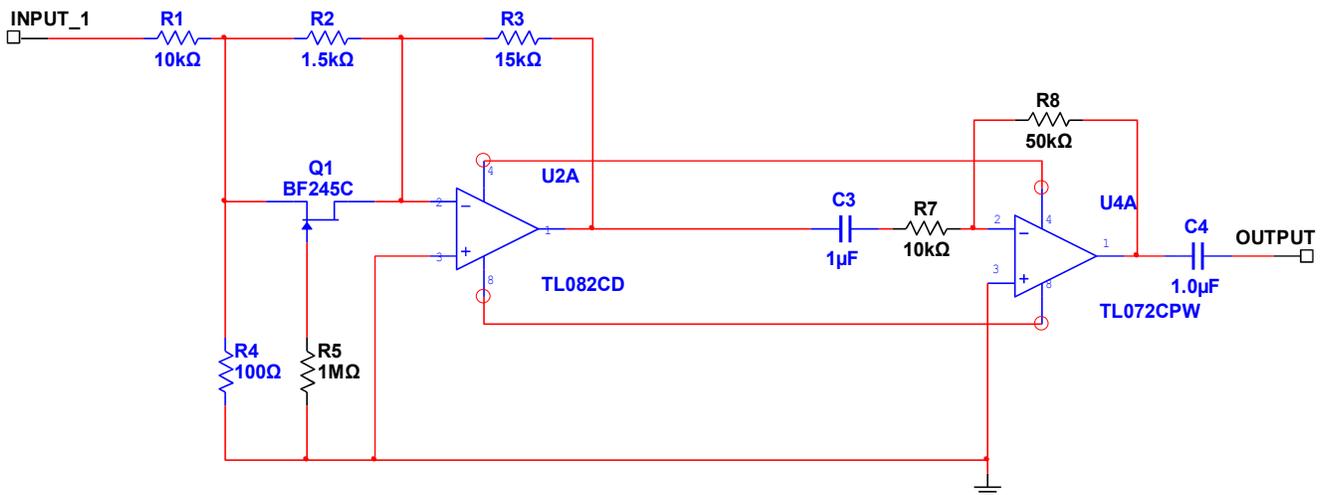


Figure 2: final proposed circuit with the removal of unnecessary parts.

## METHODOLOGY

The project was designed exclusively as a hardware application as it helped to solve delays in timing caused by a micro-controller system. I was able to implement a hardware only solution that allowed for dynamic changes in the signal while keeping the signal at the same approximate auto level. This allows for a more controlled output of the audio signal. By having a limited number of operational amplifiers and transistors that limits the distortion caused by these devices.

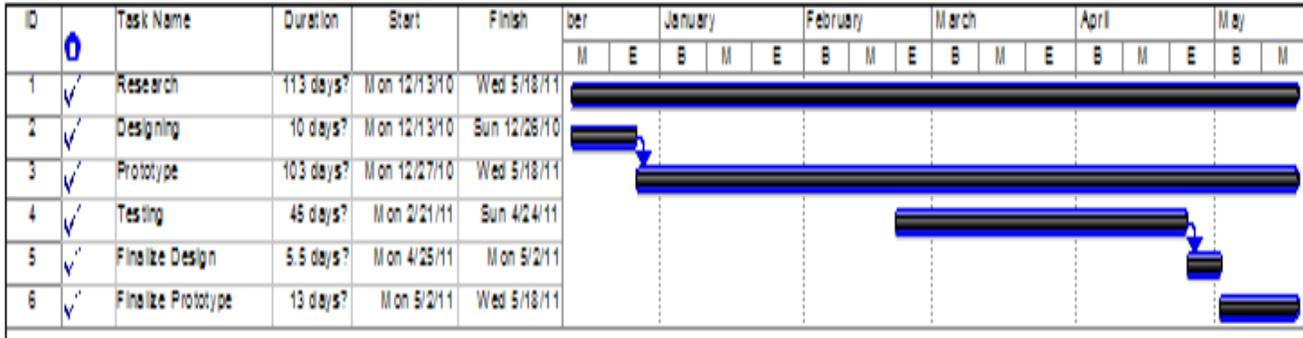


Figure 3: Gantt chart for time spent on different portions of the project

These parts are specifically for the first version of my project as it was the demonstrated project. The updated project parts list will drop the price of the project by only a few dollars.

Part	Part Number	Number of Parts	Price (each)	Price (total)
Various Resistors	N/A	11	0.006	0.06
Various Capacitors	N/A	3	0.150	0.45
Transistor	MPF102	1	0.630	0.63
Diode	1N4148	1	0.008	0.01
Op Amp	TL072CP	2	0.830	1.66
Circuit Boards	N/A	2	20	40
Casings	N/A	1	20	20
Electrolytic Cap.	N/A	1	0.82	0.82
			<b>Total</b>	<b>63.63</b>

Figure 4: Price List for the proposed project

## **PROBLEMS ENCOUNTERED**

The largest issues I had in the beginning was adequate research and the lack of information for the creation of audio circuits. After research I found that DSP's would be inadequate because of the time delay due to programming. After this I decided to create a completely electrical system. After this it was discovered that to keep the phase shift down to a minimum I needed to use a TL082 and TL071 Operational Amplifier. Other types of operational amplifiers resulted in excessive phase shifting which I was trying to keep to a minimum.

## **FINAL RECOMMENDATIONS**

This project needs to be doubled for each audio channel as it can only handle a single. This could be expanded to handle 5.1 surround sound and possibly digital audio. These updates could be as easy as doubling up modules, or as complicated as adding a microcontroller to control the outputs and gains on the outputs.

## **CONCLUSION**

The final project works better than originally expected and exceeds the original requirement. The original idea wanted to limit the dc offset and still allow dynamic range. This project completes this object and runs off of the power of the signal, requiring no external power. This means that the project can just be placed between the audio output device and speakers without the need for another plug for power. This will save more money in the long run while keeping a nice smooth audio level.

## **APPENDIX A – DATASHEETS**



## MPF102



### N-Channel RF Amplifier

This device is designed for electronic switching  
Applications such as low ON resistance analog switching.  
Sourced from Process 50.

#### Absolute Maximum Ratings \* TA=25 degree C unless otherwise noted

Symbol	Parameter	Value	Units
V <sub>DG</sub>	Drain-Gate Voltage	25	V
V <sub>GS</sub>	Gate-Source Voltage	-25	V
I <sub>GF</sub>	Forward Gate Current	10	mA
T <sub>J</sub> , T <sub>stg</sub>	Operating and Storage Junction Temperature Range	-55 to + 155	degree C

\* This ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

#### NOTES :

- 1) These rating are based on a maximum junction temperature of 150 degrees C.
- 2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

#### Thermal Characteristics TA = 25 degrees C unless otherwise noted.

Symbol	Characteristic	Max	Units
P <sub>D</sub>	Total Device Dissipation	350	mW
	Derate above 25 degrees C	2.8	mW/degrees C
R <sub>θJC</sub>	Thermal Resistance, Junction to Case	125	degrees C/W
R <sub>θJA</sub>	Thermal Resistance, Junction to Ambient	357	degrees C/W

\* Device mounted on FR-4 PCB 1.5" X 1.6" X 0.06"

**N-Channel RF Amplifier**  
(Continued)

**Electrical Characteristics** TA= 25 degrees C unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
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**OFF CHARACTERISTICS**

$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1.0\mu A, V_{DS} = 0$	-25			V
$I_{GSS}$	Gate Reverse Current	$V_{GS} = -15V, V_{DS} = 0$			-2.0	nA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15V, I_D = 2nA$			-8.0	V
$V_{GS}$	Gate-Source Voltage	$V_{DS} = 15V, I_D = 200\mu A$	-0.5		-7.5	V

**ON CHARACTERISTICS**

$I_{DSS}$	Zero-Gate Voltage Drain Current	$V_{DS} = 15V, V_{GS} = 0$	2.0		20	mA
$g_{fs}$	Forward Transconductance	$V_{GS} = 0V, V_{DS} = 15V, f = 1kHz.$	2000		7500	$\mu S$

**Capacitance**

$C_{iss}$	Common-Source Input Capacitance	$V_{GS} = 15V, V_{DS} = 0V$ $f = 1 MHz.$			7.0	pf
$C_{rss}$	Common-Source reverse Transfer Capacitance	$V_{GS} = 15V, V_{DS} = 0V$ $f = 1 MHz.$			3.0	pf

**TL081, TL081A, TL081B, TL082, TL082A, TL082B  
TL082Y, TL084, TL084A, TL084B, TL084Y**  
**JFET-INPUT OPERATIONAL AMPLIFIERS**

SLOS081E – FEBRUARY 1977 – REVISED FEBRUARY 1999

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- High Input Impedance . . . JFET-Input Stage
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/ $\mu$ s Typ
- Common-Mode Input Voltage Range Includes  $V_{CC+}$

**description**

The TL08x JFET-input operational amplifier family is designed to offer a wider selection than any previously developed operational amplifier family. Each of these JFET-input operational amplifiers incorporates well-matched, high-voltage JFET and bipolar transistors in a monolithic integrated circuit. The devices feature high slew rates, low input bias and offset currents, and low offset voltage temperature coefficient. Offset adjustment and external compensation options are available within the TL08x family.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 85°C. The Q-suffix devices are characterized for operation from –40°C to 125°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C.

**symbols**



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**TL081, TL081A, TL081B, TL082, TL082A, TL082B  
TL082Y, TL084, TL084A, TL084B, TL084Y  
JFET-INPUT OPERATIONAL AMPLIFIERS**  
SLOS081E – FEBRUARY 1977 – REVISED FEBRUARY 1999

