ELG 4135 Electronics III Project

Personal Music Station with Equalizer

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Introduction

What we did?

Design a Personal Music Station with Equalizer.

- The station can connect our audio devices and radios.
- The equalizer allows us to fine-tune an audio by increasing or decreasing the volume within a specified band.
- The equalizer can be used in conjunction with the AM transmitter, or can be used separately.

Introduction

What can equalizer do?

- Equalizer are common audio effect devices. It can alter the spectral content of a audio signal.
- With an equalizer, we can minimize noise recorded in the field, boost the weak audio recorded from a camcorder mike, and add impressive clarity to a poorly soundtrack.

Introduction

We present an equalizer.

- Simple circuit.

  Just combine some simple electronics components to achieve the equalizer function.
- Convenient to build.

  No programmable chip used. just some amplifiers, resistors, and capacitors. All the components can be found in our laboratory.

Introduction

Compare our design with a product in the market

Our Design
Personal Music Station with 5-Band Equalizer
For All players

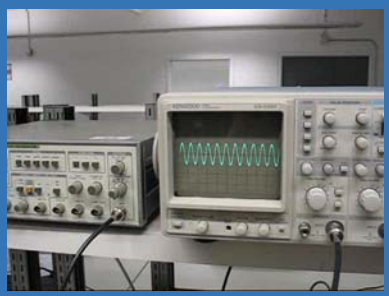
EQ-50 Koss
iPod 3-Band Stereo Equalizer
For All iPods

Introduction

The feature of our design

- Five-band intervals equalizer.
  0 - 2 KHz, 2 - 4 KHz, 4 - 6 KHz, 6 - 8 KHz, and 8 KHz up
- LEDs indicator.
  Indicate what level of volume in a specific band is playing.
- AM transmitter.
  Transmit the audio signal to a radio.
- The recommended power supply is ±15V.

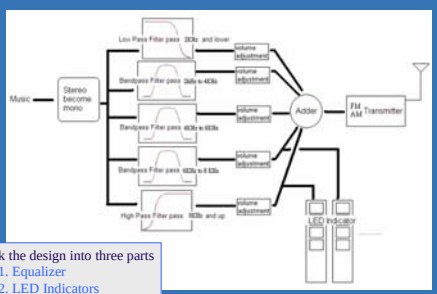
Introduction



System Description

- This circuit uses some amplifiers, resistors, and capacitors for realizing a five band equalizer in our audio system.
- The five center frequencies are independently set using capacitors.
- The output stage amplifiers are independent circuits, fine control over a part of frequency bandwidth is possible.

System Description



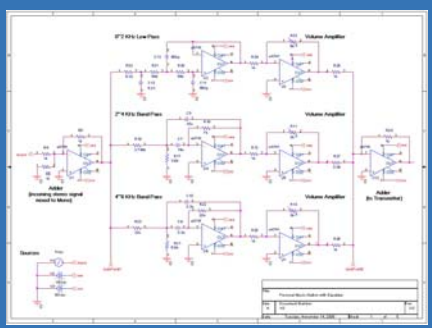
Break the design into three parts
Part 1. Equalizer
Part 2. LED Indicators
Part 3. AM/FM Transmission

Design - Equalizer

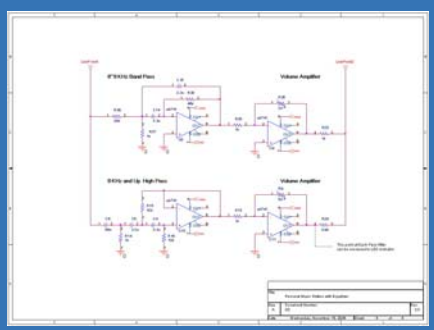
Part 1. Equalizer

- Adder
  Turn Stereo into Mono
- Filters
  Cut the music into different bands
- Amplifier
  Tune Voltage level at each band
- Adder
  Add all outputs from each band

Design - Equalizer

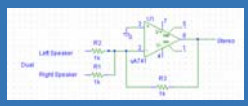


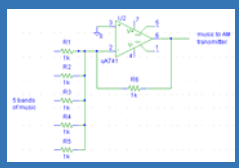
Design - Equalizer



Design - Equalizer

- Adder





  - Add multiple channels of music together.
  - All resistors were chosen to be the valve 1k Ω , since no amplification needed.

Design - Equalizer

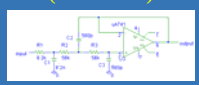
- Low Pass Filter & High Pass Filter

  Initial we used second order Filter, but it didn't eliminate the cut-off frequency signal as small as possible, so we adopted a third order filter later.

1. First, using KCL to calculate the transfer function.
2. Let C2=C3, R2=R3; then determine R1 and C1.
3. Calculating by Matlab, we can find the value of R2, and C2 according to frequency range.

Design - Equalizer

- Low Pass Filter (0 – 2 KHz)



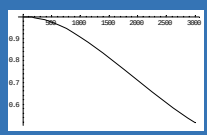
$$\frac{Vo}{Vin} = \frac{1}{[1+s(C1R1+C3R1+C3R2+C3R3)+s^2(C1C3R1R2+C1C3R1R3+C2C3R1R3+C2C3R2R3)+s^3(C1C2C3R1R2R3)]}$$

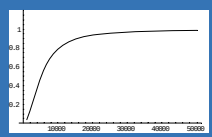
- High Pass Filter (8 KHz up)

$$\frac{Vo}{Vin} = \frac{s^3C1C2C3R1R2R3}{[s^3C1C2C3R1R2R3+s^2(C2C3R2R3+C2C1R2R1+C1C3R2R1+C2C3R2R1)+s(C2R2+C3R2+C1R1+C2R1)+1]}$$

Design - Equalizer

- Calculated Low & High Pass Filter transfer function (V_o/V_{in})

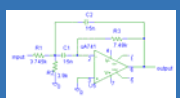




Low Pass Filter (2 KHz below) *High Pass Filter* (8 KHz up)

Design - Equalizer

- Band Pass Filters



Three Band Pass were implemented

Band Pass Filter (2 – 4 KHz)
Band Pass Filter (4 – 6 KHz)
Band Pass Filter (6 – 8 KHz)

Design - Equalizer

The design process for band filter was different from that of Low Pass and High Pass filter. We utilized another approach posting on eCircuit Center website.
("http://www.ecircuitcenter.com/Circuits/MFB_bandpass/MFB_bandpass.htm")

fo : Center frequency.
BW = fH - fL : Bandwidth.
Q = fo / BW : Quality factor.
H = Vo / Vin : Mid-band Gain.

Choose C = C1 = C2, we have k= 2 π *f0*C. Then

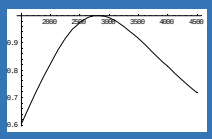
$$R1 = \frac{Q}{H * k}$$

$$R2 = \frac{Q}{(2Q^2 - H)k}$$

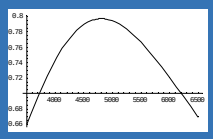
$$R3 = \frac{2Q}{k}$$

Design - Equalizer

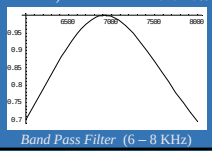
- Calculated Band Pass Filters transfer function (V_o/V_{in})



Band Pass Filter (2 – 4 KHz)



Band Pass Filter (4 – 6 KHz)



Band Pass Filter (6 – 8 KHz)

Design - Equalizer

- Voltage amplifier

  we use inverting amplifiers to be the volume amplifiers.

  - The gain of the output with respect to input is determined by G = R2/R1.
  - The gains of the different bands of the equalizer are controlled with potentiometer R2

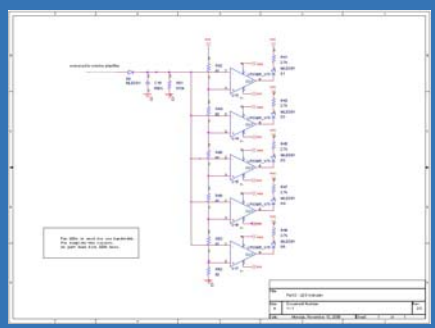
Design - LED

Part 2. LED indicator

- Comparator

  Compare the voltage between non-inverting input and inverting input.

Design - LED



Design - LED

LED indicator was used for to instruct us to how much amount of volume to increase or decrease.

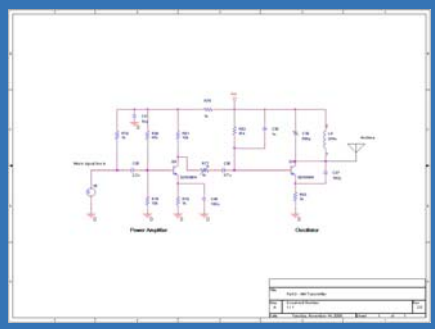
- Ten LEDs for each bandwidth. We divided the maximum amplitude evenly into ten.
- Comparators were utilized. Comparison between non-inverting input and inverting input.
- To have the even voltage differences between every non-inverting input, resistor values are with equal amount.

Design - AM Transmitter

Part 3. AM Transmitter

- Power Amplifier
- Colpitts Oscillator

Design - AM Transmitter



Design - AM Transmitter

This circuit is in two half

- Audio amplifier

  This amplifier is wired as a common emitter amplifier, and the amount of AM modulation is adjusted with the potentiometer.

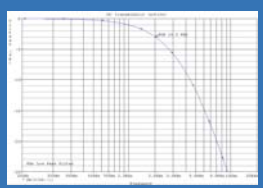
- Colpitts Oscillator

$$f_o = \frac{1}{2\pi\sqrt{L_1(\frac{C1}{2})}}$$

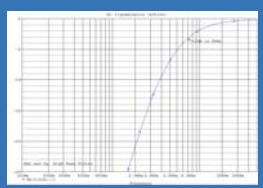
The circuit is tunable from about 500 KHz to 1600 KHz. Oscillation frequency is adjusted with C1.

Result - Practical transfer function

- Practical Low & High Pass Filter transfer function (V_o/V_{in})



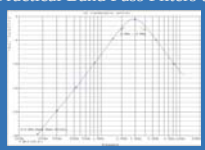
Low Pass Filter (2 KHz below)



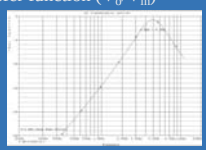
High Pass Filter (8 KHz up)

Result - Practical transfer function

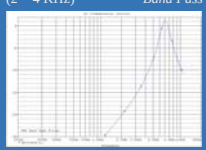
- Practical Band Pass Filters transfer function (V_o/V_{in})



Band Pass Filter (2 – 4 KHz)

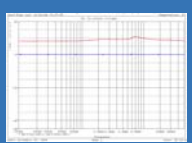


Band Pass Filter (4 – 6 KHz)

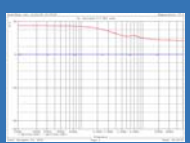


Band Pass Filter (6 – 8 KHz)

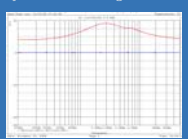
Result - Input Signal and Output Signal



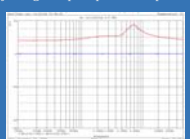
All adjacent bands configured to same gain



Adjusting low pass power Amplifier only

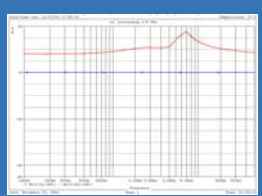


Adjusting band 2-4 KHz Amplifier only



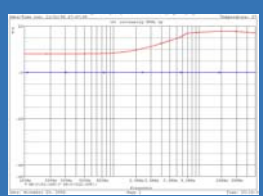
Adjusting band 4-6 KHz Amplifier only

Result - Input Signal and Output Signal



Amplifier Band signal (6 – 8 KHz)

Adjusting band 6-8 KHz Amplifier only



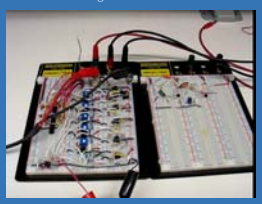
Amplifier High frequency signal (8 KHz up)

Adjusting high pass power Amplifier only

Result - Demo

What happened in the demo?

We demo High Pass Filter in the video



1. Before adjusting sub-bands power amplifiers, the output signal just remains at the same level if two adjacent bands are configured to same gain.
2. Now, we adjust the potentiometer of the high pass band.
3. At 10 KHz, We can see the amplitude is amplified.
4. Then we decrease the frequency. We observed that the amplitude of output remains at the same level. However, when frequency drops to 8 KHz, the amplitude decrease sharply, and the amplitude is close to the original input.

This demo result proves the simulation result in the previous slide!

Conclusion

- During the project, we learned a great deal of concepts and implementation. We utilized a lot of the concepts we have learned about electronics.
- We have met some problems during the project. Finally, we finished this project successfully.

Reference

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Thanks

We feel deep appreciation for TA Peng He and Mohamad Eid

-- They guided us through out the Design Project. Their helps were beneficial in the success of our project.

A special thanks goes to Professor Riadh Habash

-- We learned a lot from his teaching that will be very useful in our future work in design.

Thank You All !

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