Project Report on

Simulation & Analysis Of A Three Channel Audio Equalizer

For the evaluation of innovative work for MTE component

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AE EC-261

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INDEX

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We would also like to express heartfelt thanks to the people who are directly and indirectly part of this project. We have to thank our subject teacher **Prof. Lokesh Gautam** for his help by providing the essential suggestions, help and the solution for the problem during project development.

ABSTRACT

Introduction

Audio in practical situations often consists of sounds of different frequencies mixed. Equalizers are used in such situations to correct/adjust the response of the audio device emphasizing some frequencies over the others. Each equalizer has a different purpose and characteristic sound. The most well known use of equalization is in sound recording and reproduction but there are many other applications in electronics and telecommunications.

Objectives

The project aims at studying about audio equalizers and filters, their construction, operation and various applications. Finally we simulate and analyze a three-channel/band audio equalizer using a suitable electronic design simulation software and studying the corresponding input-output waveforms.

PRINCIPLE

Filter Circuits

Filters are considered to be one of the basic building blocks of signal processing. In general, a filter is considered to be any device or circuit that changes the tone, or timbre of an audio signal.

Filters are so named according to the frequency range of signals that they allow passing through them while blocking or “attenuating” the rest. The most commonly used filter designs are the:

- **Low Pass Filter** – the low pass filter only allows low-frequency signals from 0Hz to its cut-off frequency, fc point to pass while blocking those any higher.
- **High Pass Filter** – the high pass filter only allows high-frequency signals from its cut-off frequency, fc point, and higher to infinity to pass through while blocking those any lower.
- **Band Pass Filter** – the band-pass filter allows signals falling within a certain frequency band set up between two points to pass through while blocking both the lower and higher frequencies on either side of this frequency band.
- **Notch Filter** – the notch filter stops signals falling within a certain frequency band set up between two points to pass through while allowing both the lower and higher frequencies on either side of this frequency band.

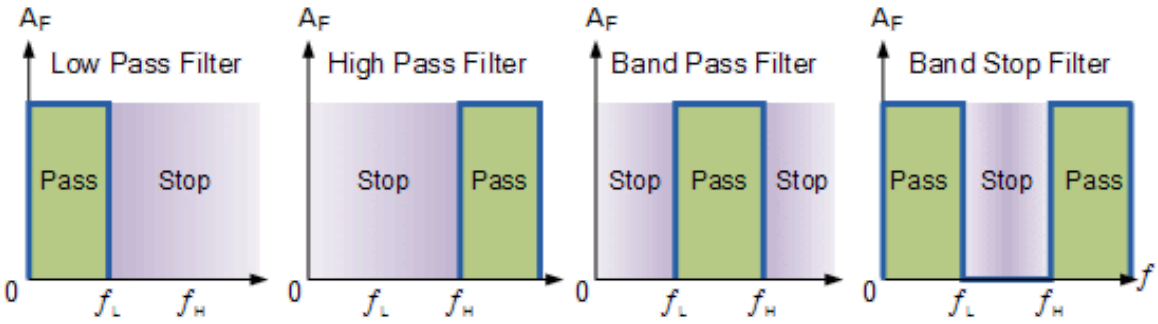
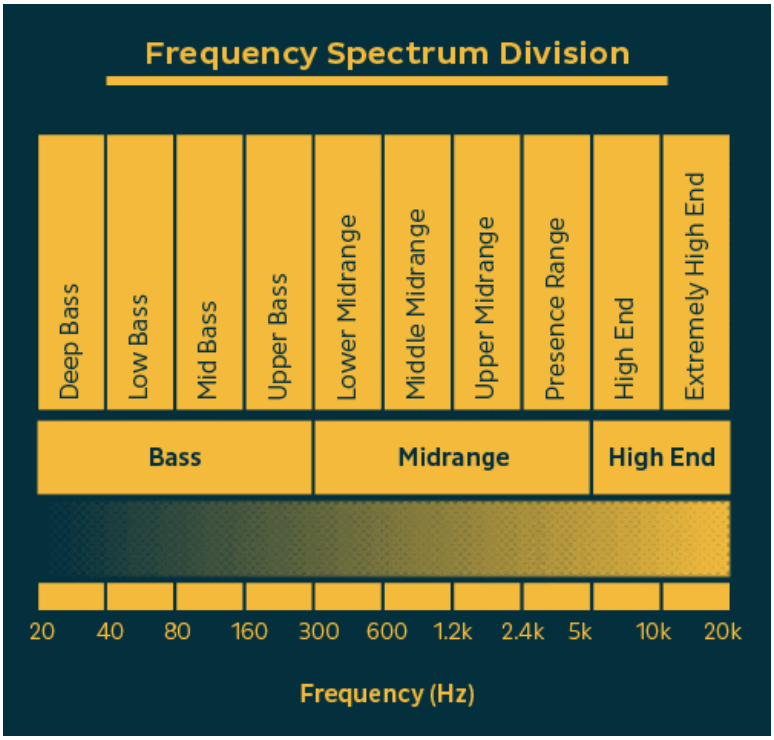


Fig. Ideal Filter Response curves

Passive filters in contrast to active filters, are made up of passive components such as resistors, capacitors, and inductors and have no amplifying elements (transistors, op-amps, etc) so have no signal gain, therefore their output level is always less than the input.



Equalizers

Equalization is the process of adjusting the balance between frequency components within an electronic signal. The circuit or equipment used to achieve equalization is called an equalizer.

These devices strengthen or weaken the energy of specific frequency bands or ranges. Filtering out lower frequencies improves treble while filtering out higher frequencies improves the bass of the sound.

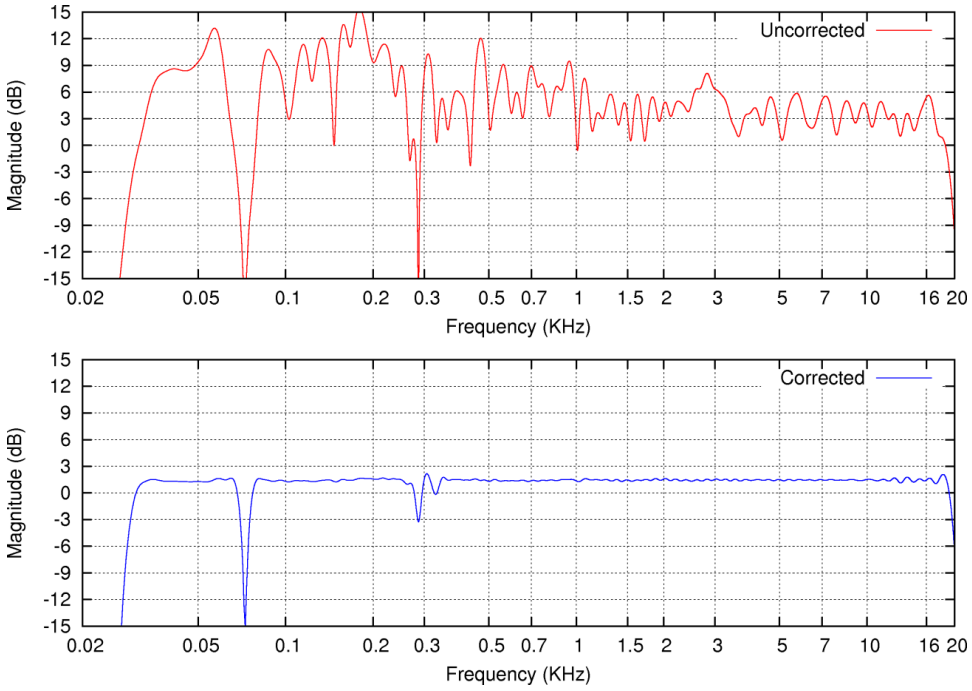


Fig. Removal of White Noise Produced by Imperfect Speakers using Equalizers

While there are many types of audio equalizers, the two most common are graphic and parametric:

- **Graphic Equalizers** – In the graphic equalizer, the input signal is sent to a bank of filters. Each filter passes the portion of the signal present in its own frequency range or band. The amplitude passed by each filter is adjusted using a slide control to boost or cut frequency components passed by that filter.
- **Parametric Equalizers** – Parametric equalizers are more complex than graphic equalizers since we can make additional adjustments beyond volume like levels (boosting or cutting decibels), the center/primary frequency, and bandwidth/range (also known as Q or quotient of change) of each frequency.

Graphic Equalizer	Parametric Equalizer
Simple and intuitive operation	Complex and deliberate operation
Fixed frequency adjustment	Select frequency adjustment
A Broad range of effect	Precise range of effect
Ideal for general use	Ideal for studio recording, mixing, and/or production
Typically less expensive than parametric equalizers	Typically more expensive than graphic equalizers

A Three-Channel Audio Equalizer consists of a low-pass filter, a band-pass filter, and a high-pass filter. Input signal is divided into three parts each of which passes through the three filters. A potentiometer can be used as a variable resistor to act as volume control for each filter. Current from all three filters is summed and amplified using an amplifier.

Capacitive Filtering Operation

Capacitors are often used in such filtering operations because of the inverse relation of their capacitive reactance with frequency passing through. Using capacitors and resistors wisely can help create various filters.

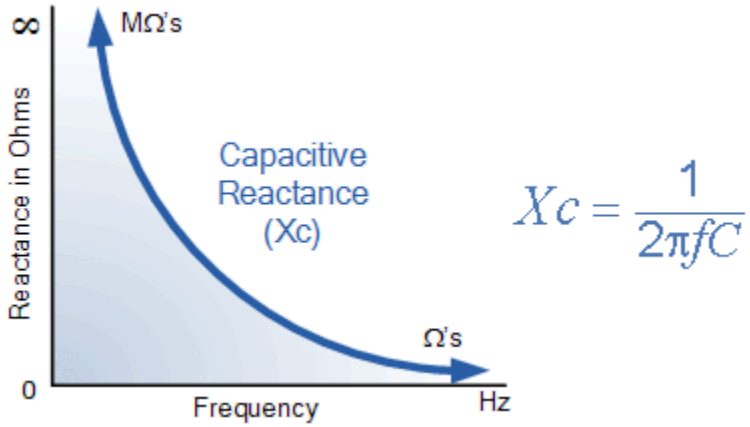


Fig. Capacitor Reactance-Frequency curve

Low-Pass Filter

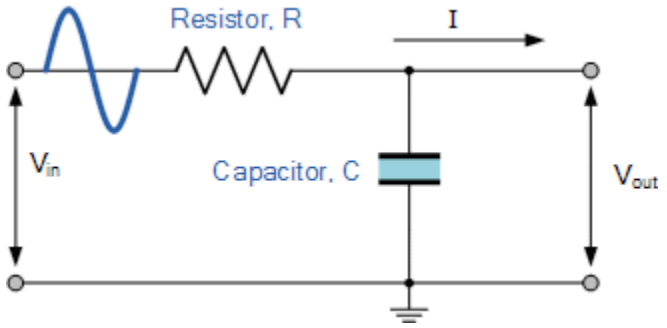


Fig. RC Low-Pass Filter Circuit

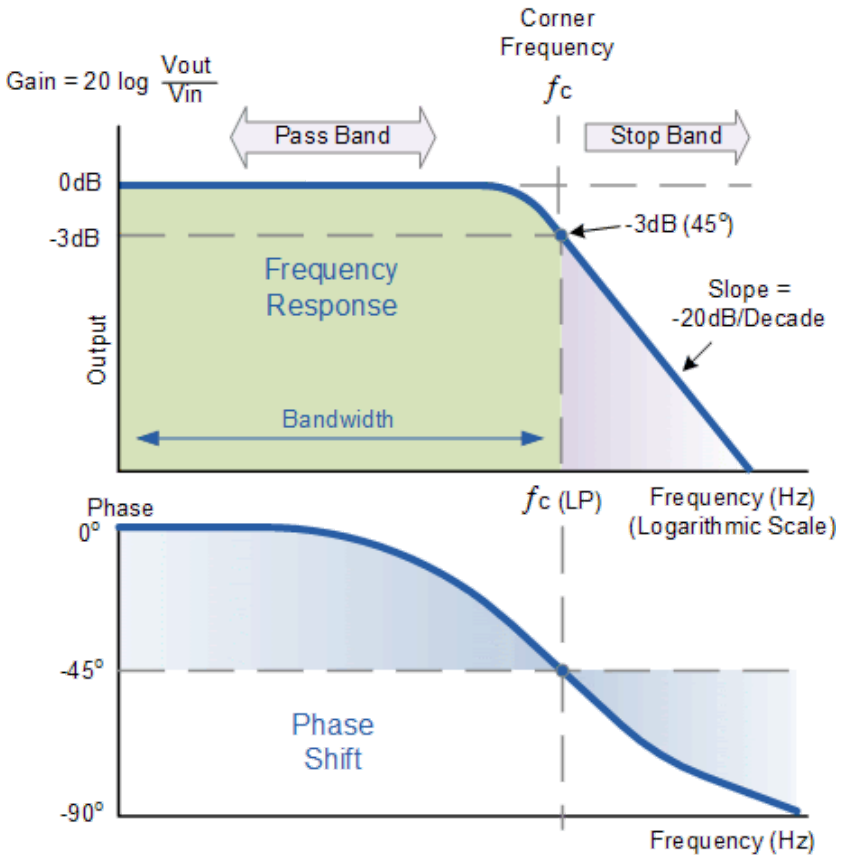


Fig. Frequency Response of a 1st-order Low-Pass Filter

High-Pass Filter

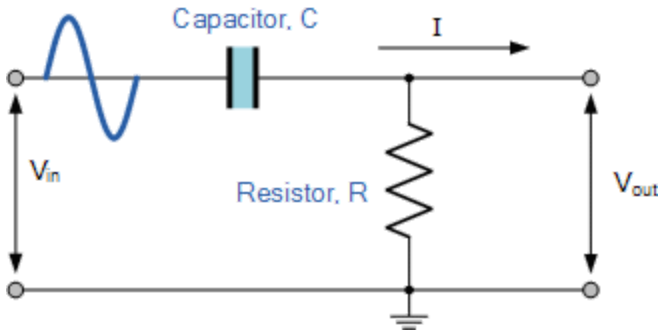


Fig. RC High-Pass Filter Circuit

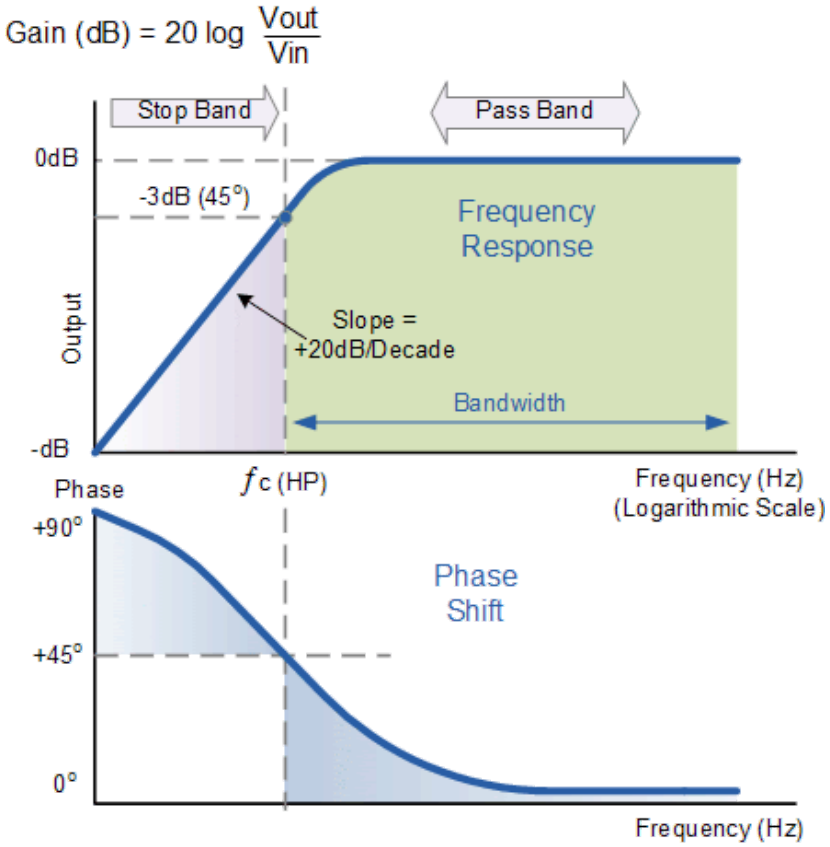


Fig. Frequency Response of a 1st-order High-Pass Filter

Band-Pass Filter

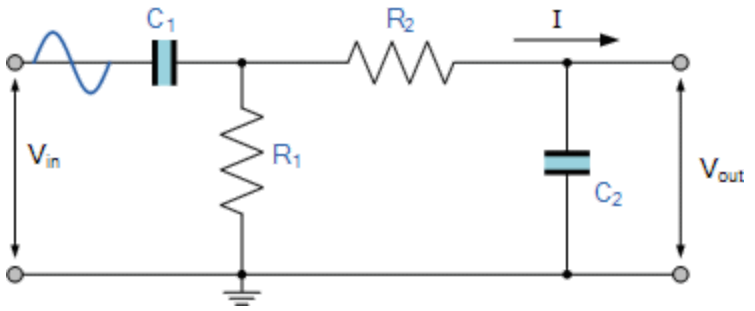


Fig. RC Band-Pass Filter Circuit

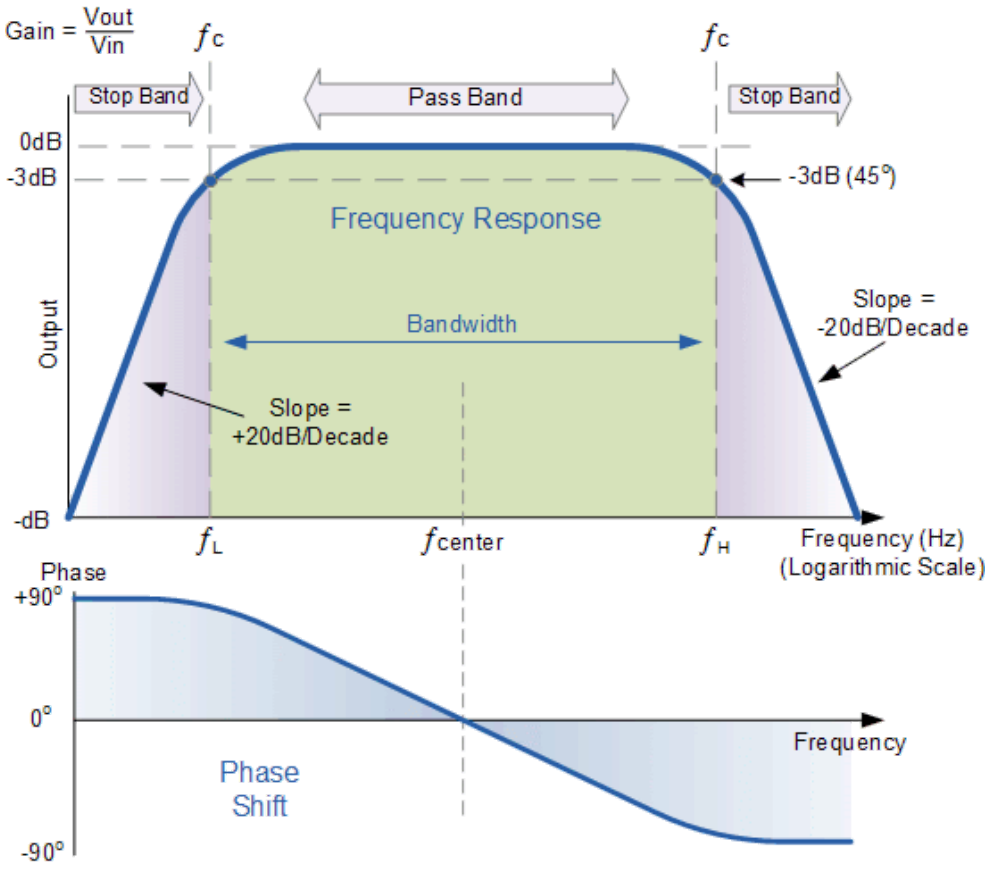


Fig. Frequency Response of a 1st-order Band-Pass Filter

3-Phase Audio Equalizer

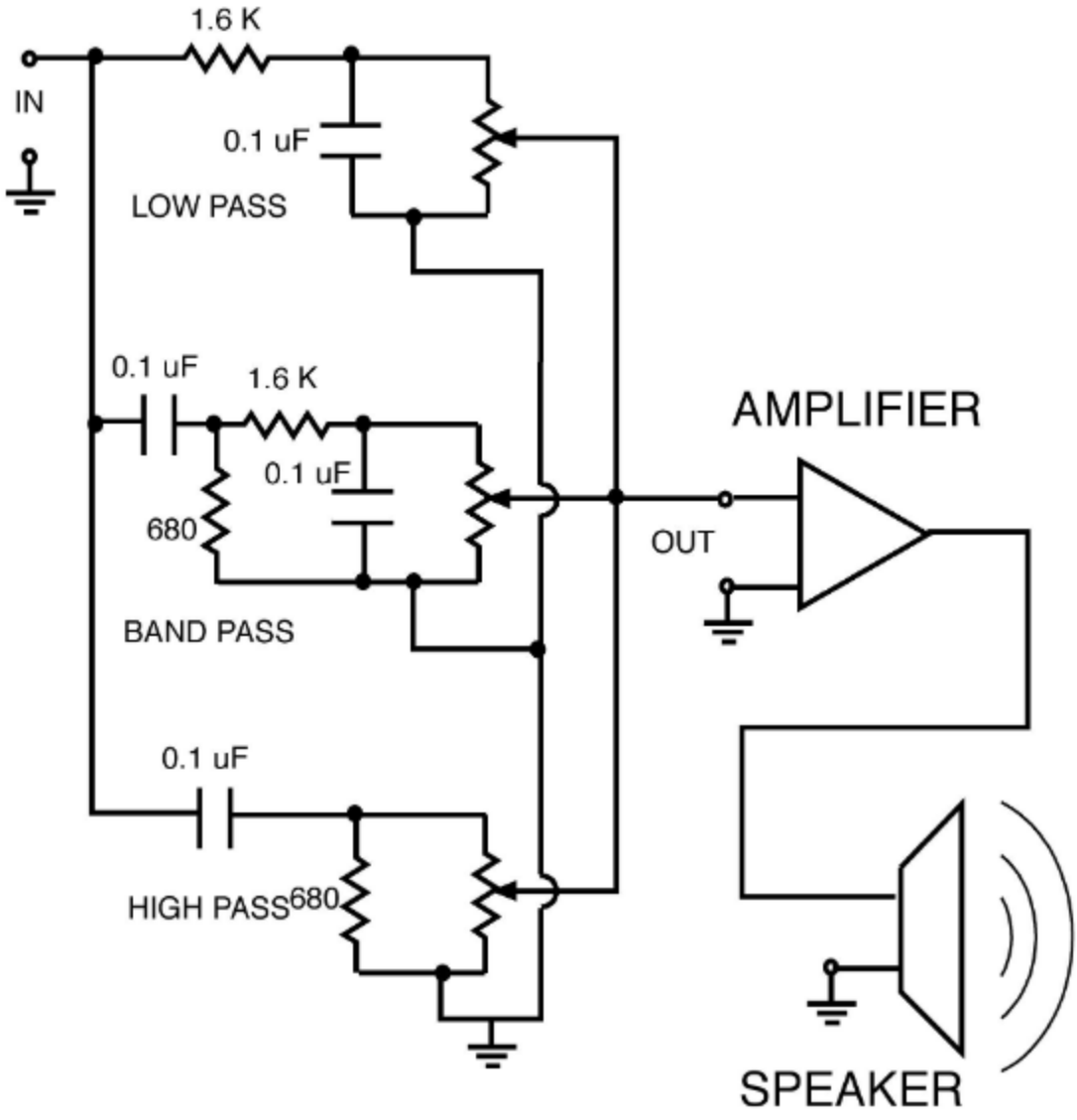
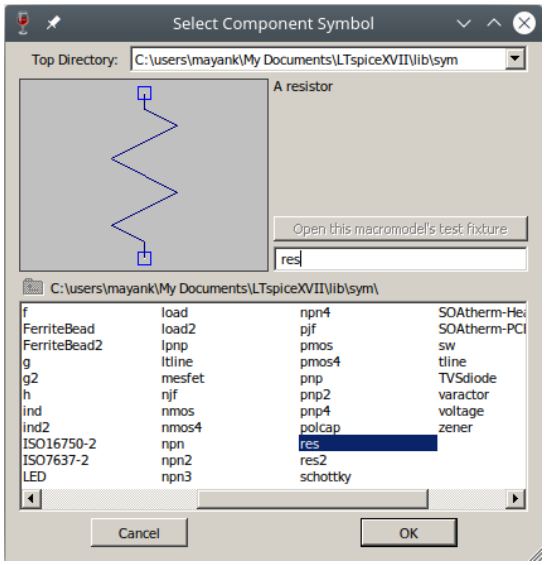
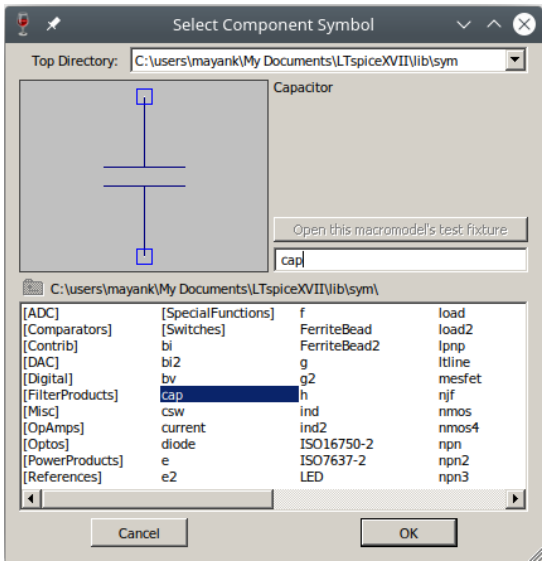


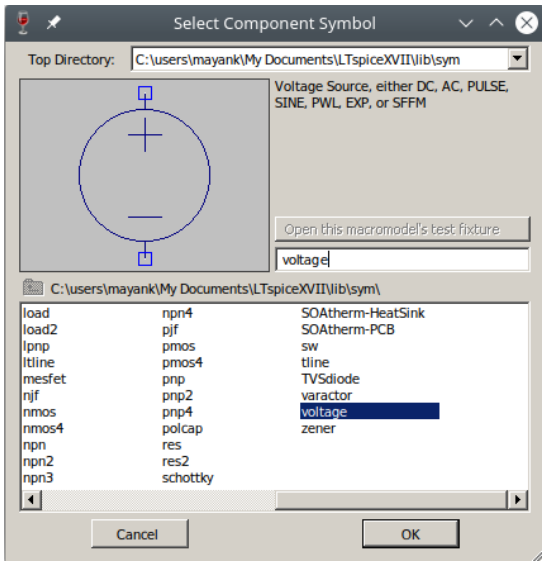
Fig. 3-Phase Audio Equalizer Circuit Diagram

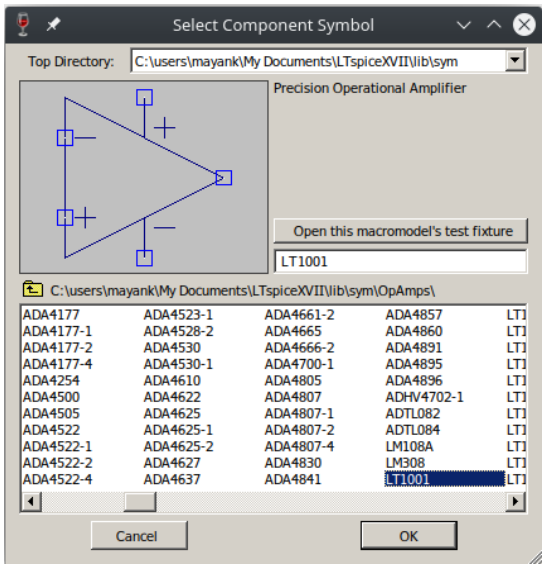
SIMULATION & ANALYSIS

Components Used









Low-Pass Filter

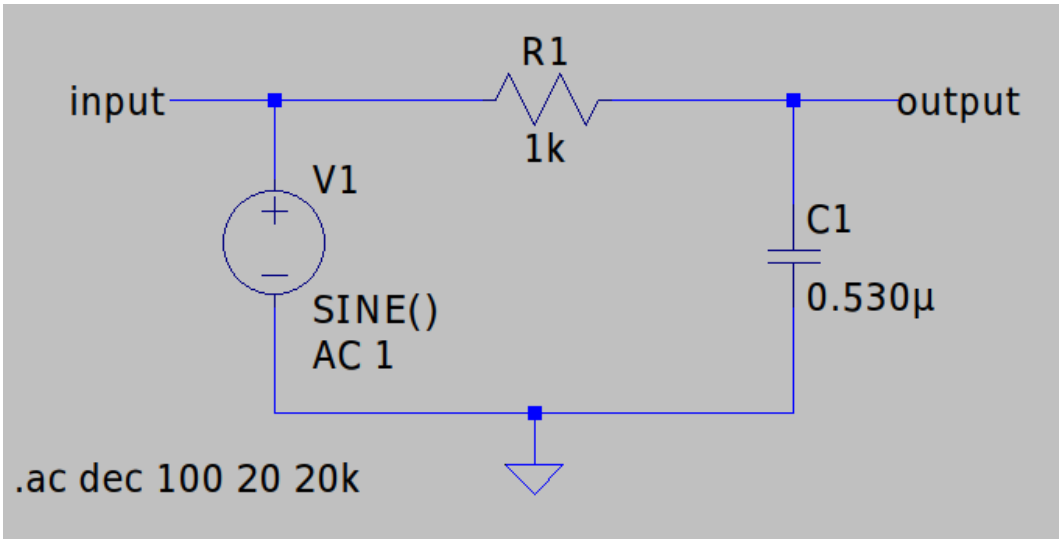


Fig. AC Analysis Circuit for Low-Pass Filter

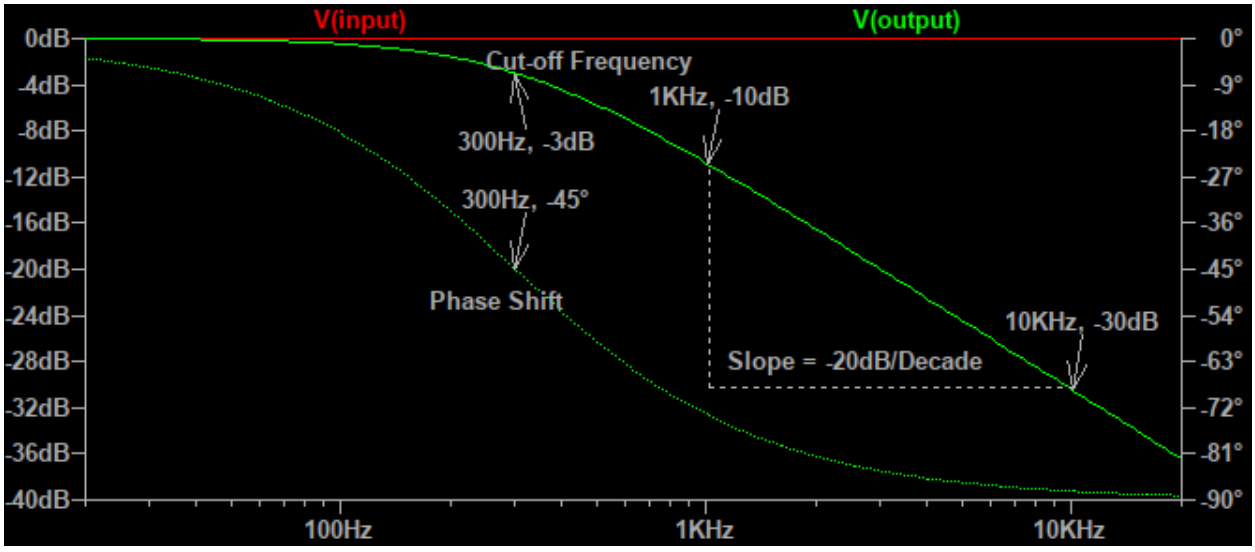


Fig. AC Analysis Plot for Low-Pass Filter

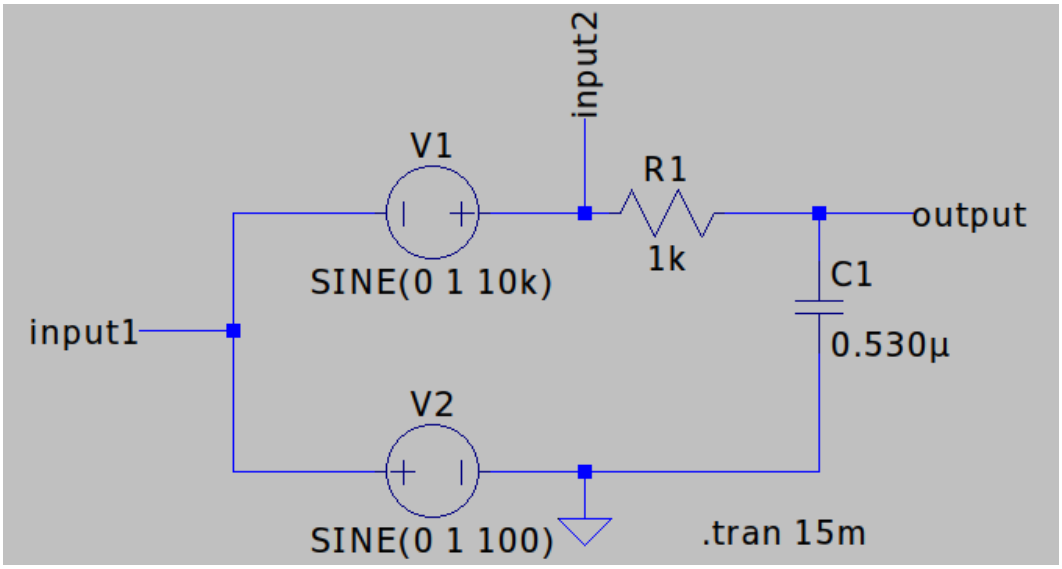


Fig. Transient Analysis circuit for Low-Pass Filter

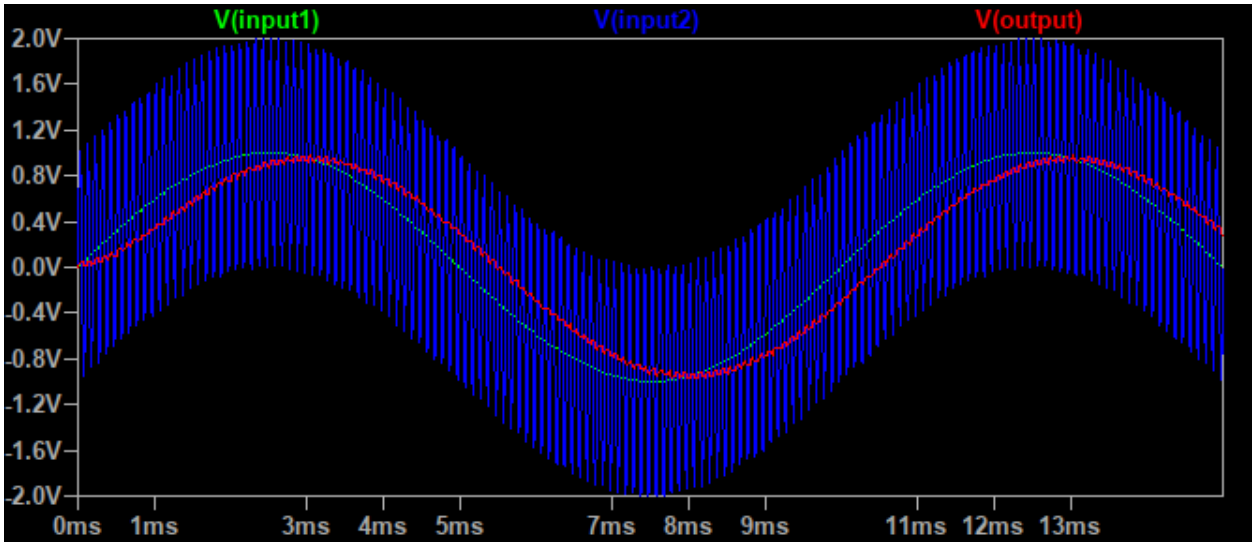
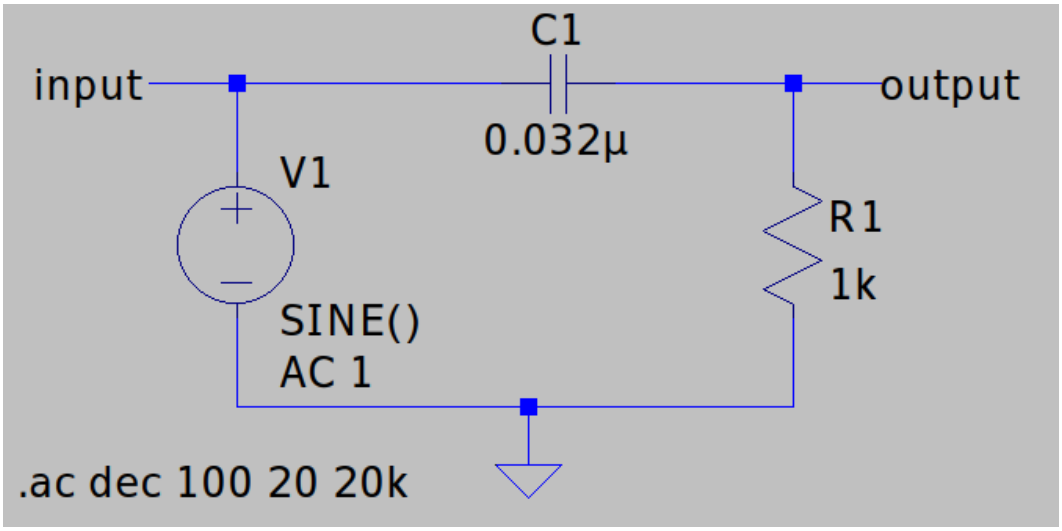


Fig. Transient Analysis Plot for Low-Pass Filter

High-Pass Filter



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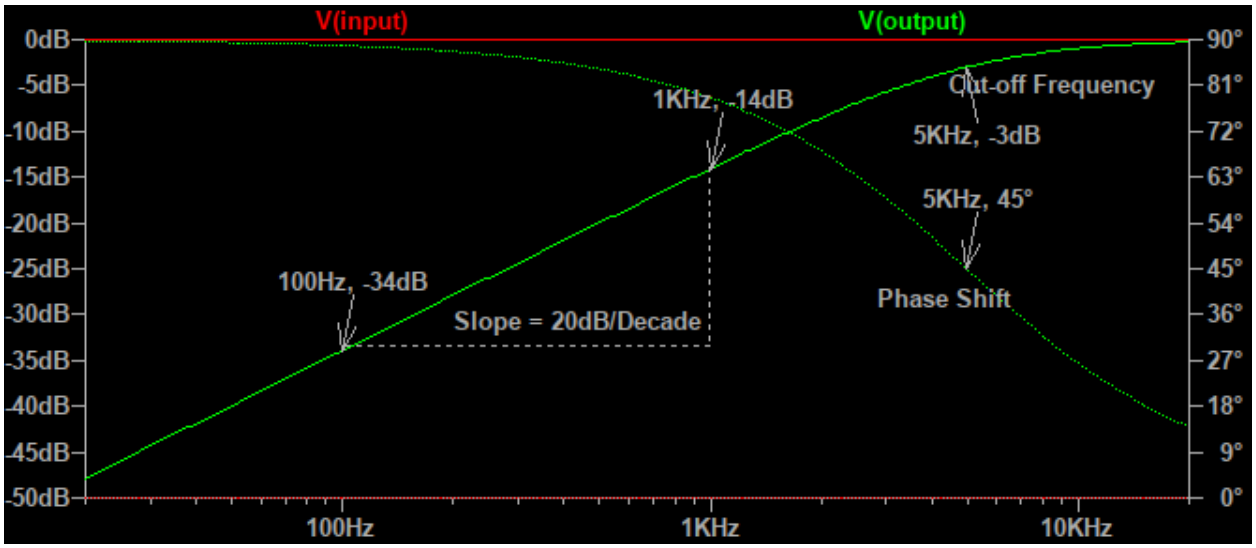

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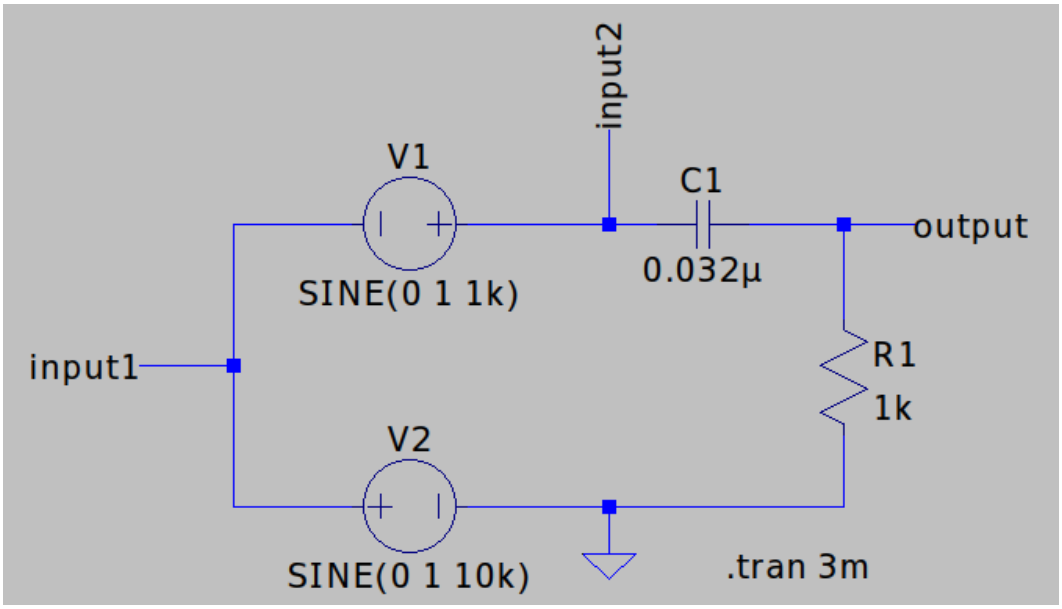

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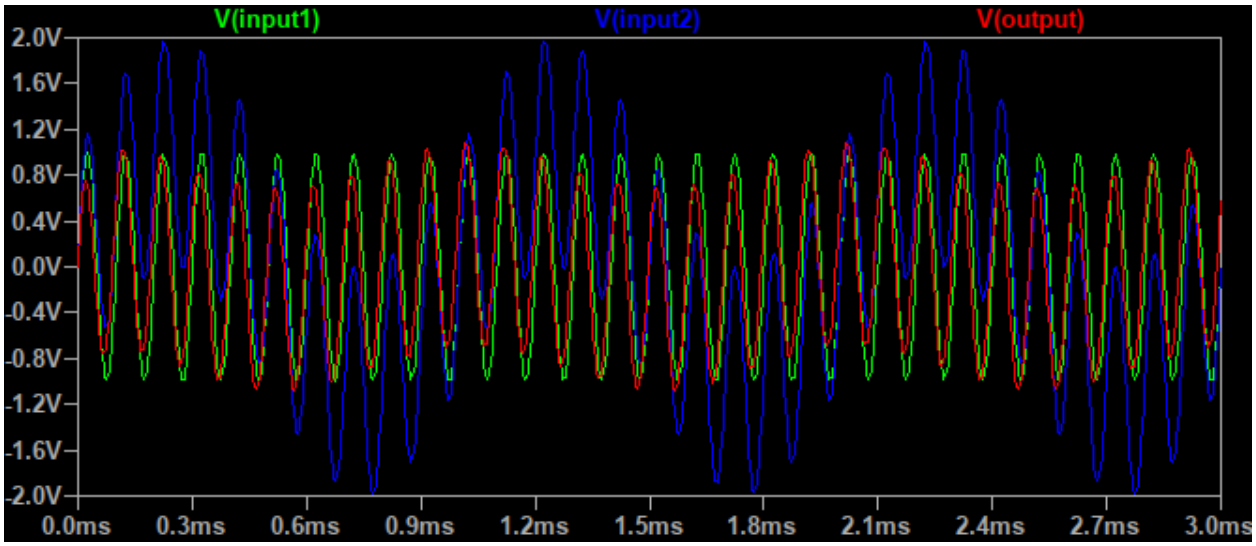


Fig. Transient Analysis Plot for High-Pass Filter

Band-Pass Filter

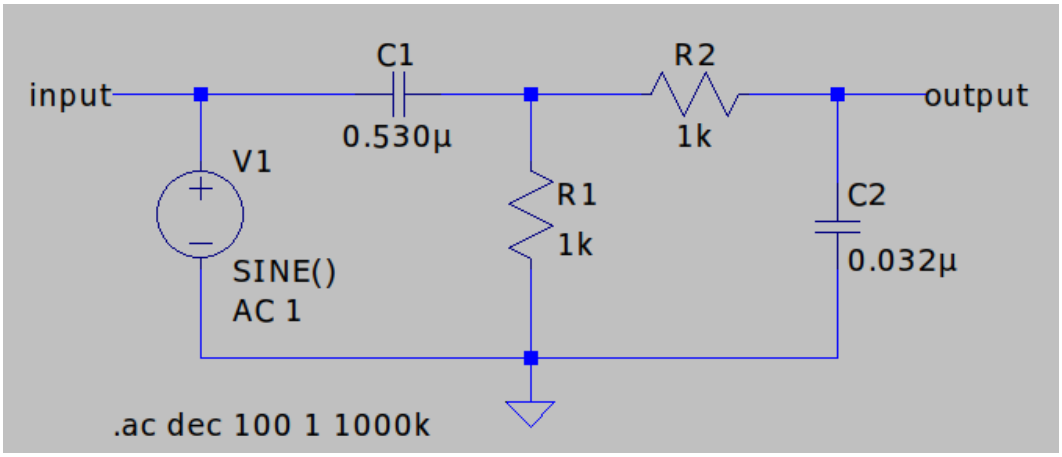


Fig. AC Analysis Circuit for Band-Pass Filter

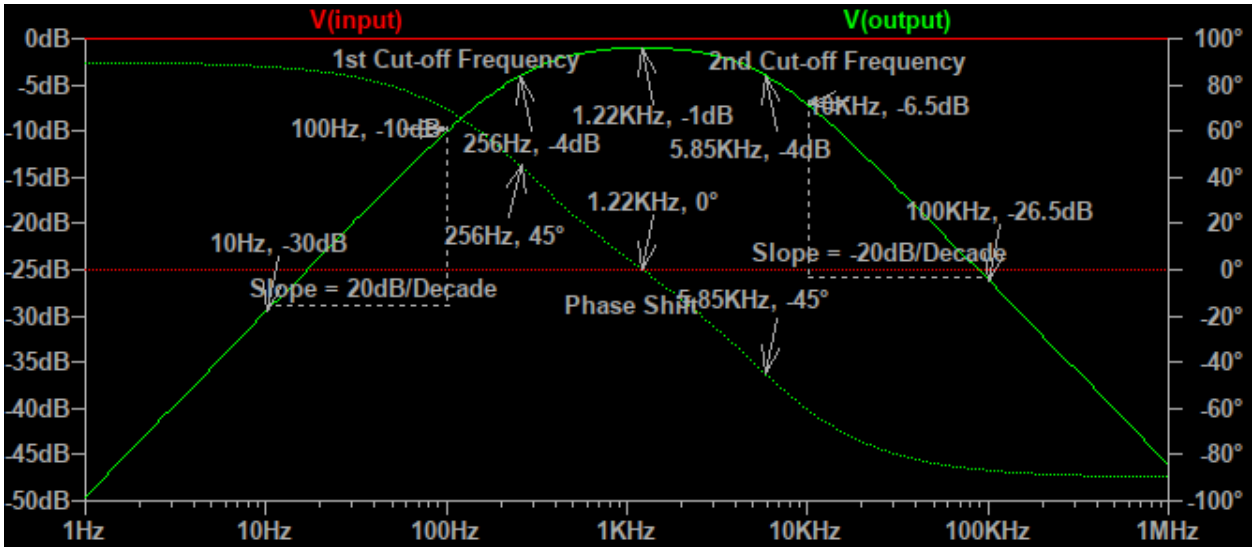
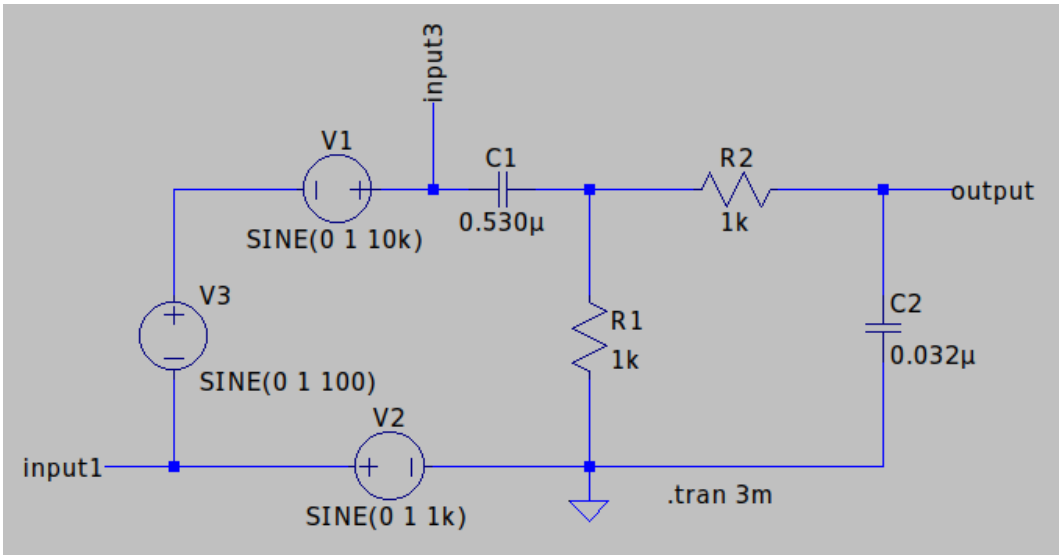


Fig. AC Analysis Plot for Band-Pass Filter



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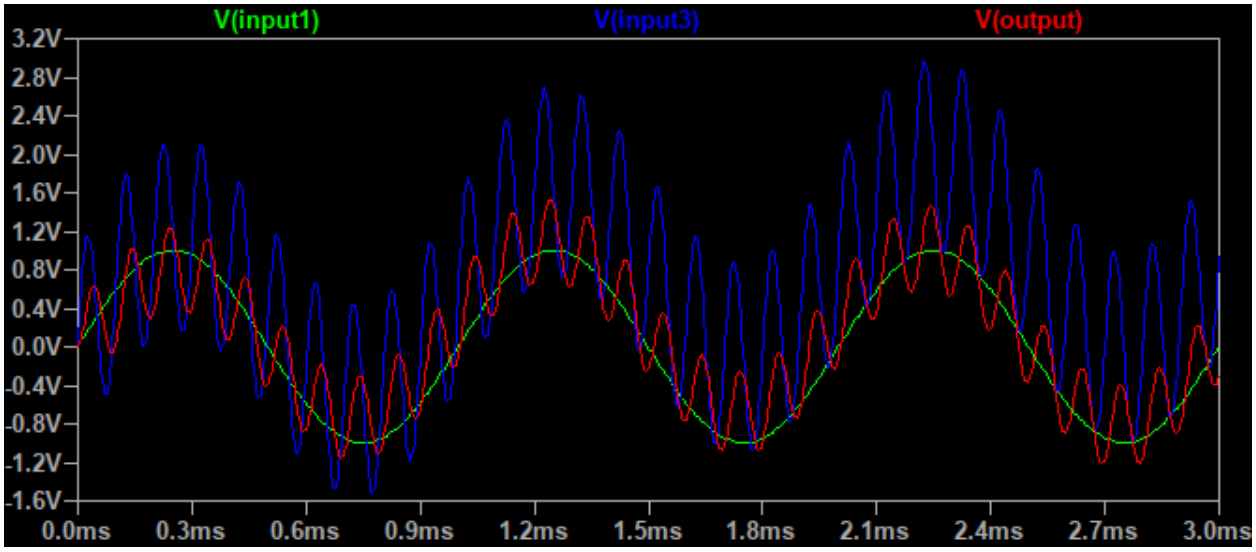

Fig. Transient Analysis Plot for Band-Pass Filter

3-Phase Audio Equalizer (Low-Pass Testing)

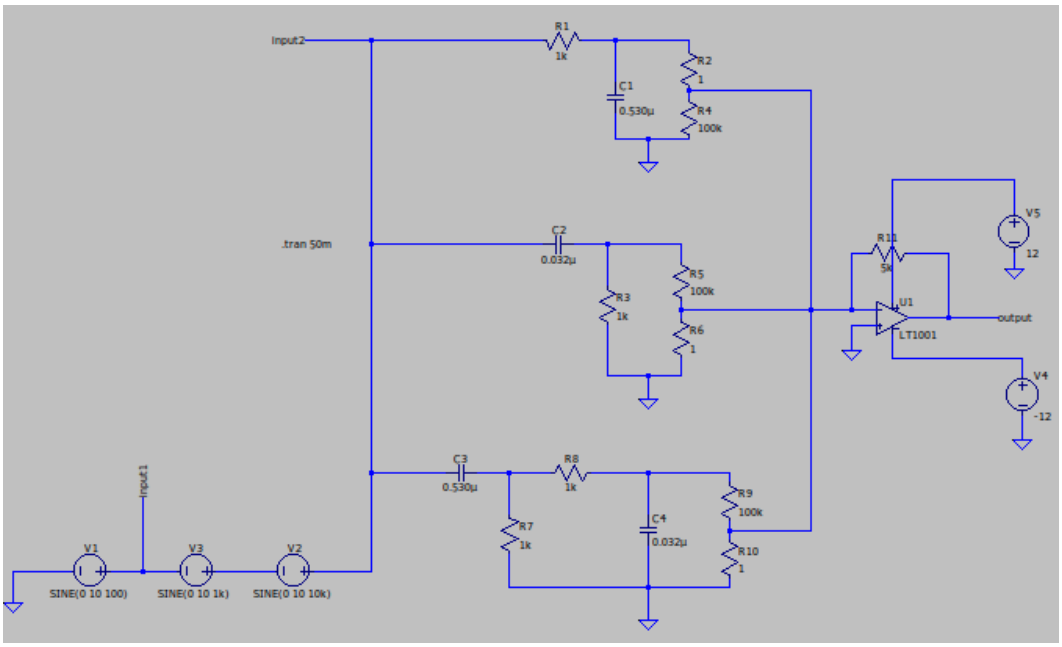

Fig. Transient Analysis Circuit for 3-Phase Audio Equalizer (Low-Pass Testing)

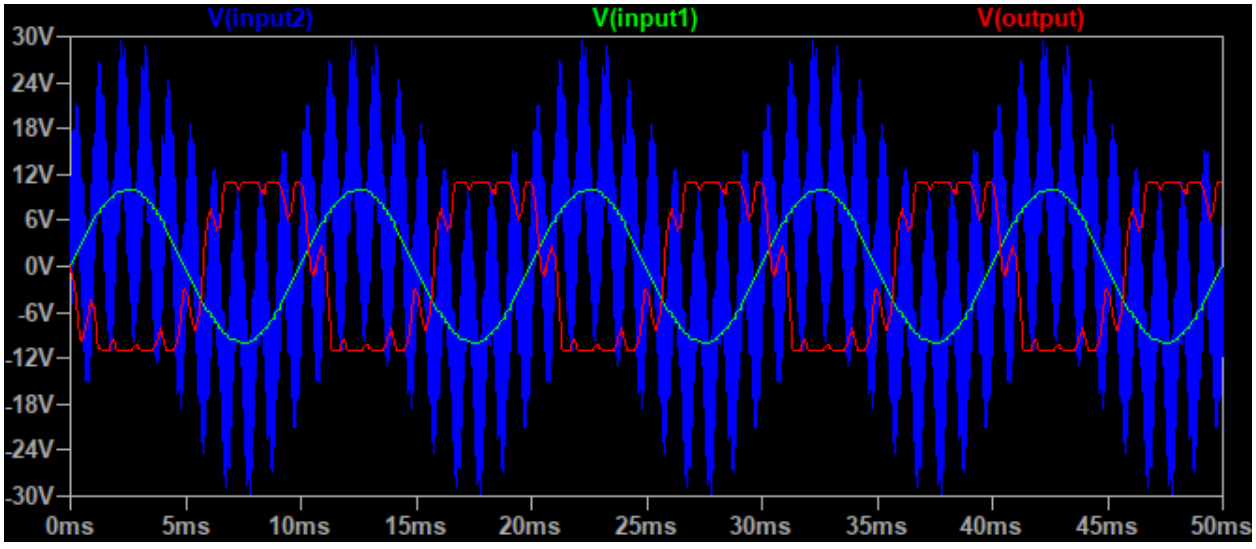

Fig. Transient Analysis Plot for 3-Phase Audio Equalizer (Low-Pass Testing)

3-Phase Audio Equalizer (High-Pass Testing)

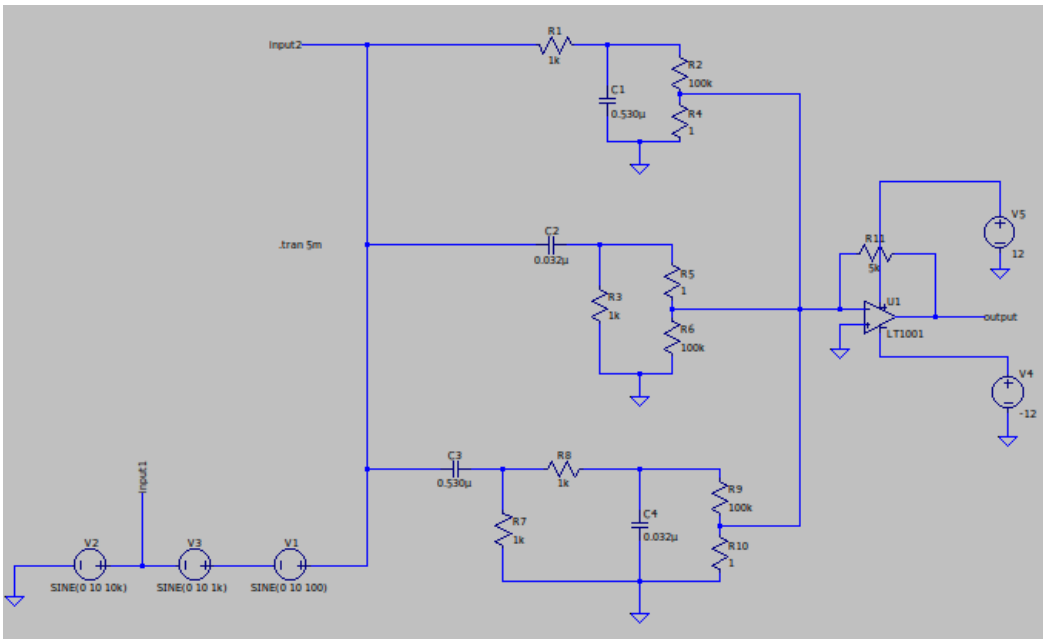

Fig. Transient Analysis Circuit for 3-Phase Audio Equalizer (High-Pass Testing)

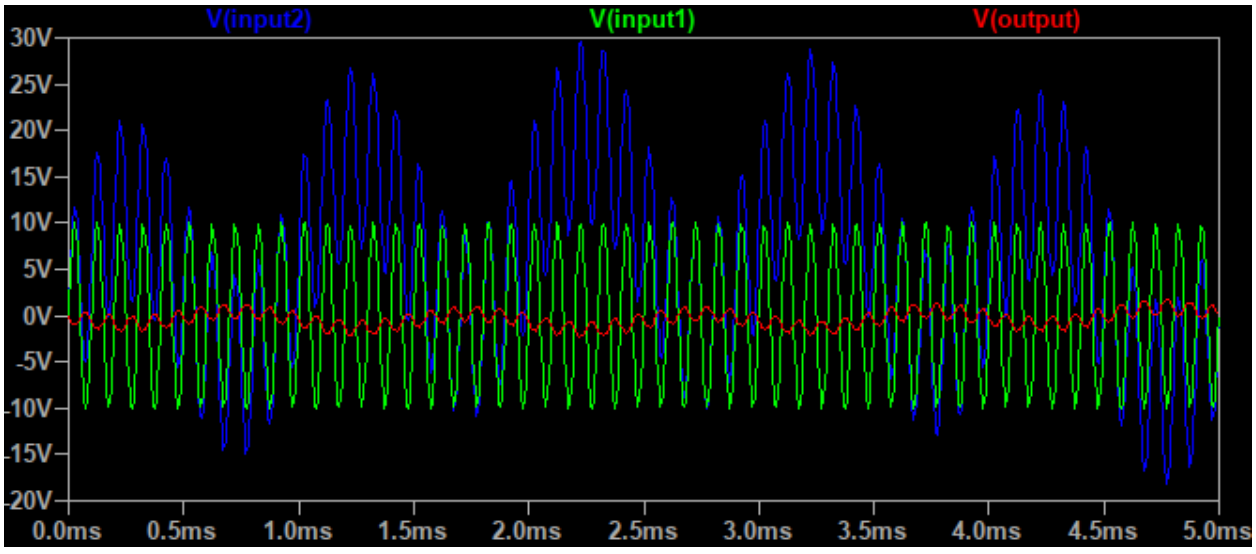

Fig. Transient Analysis Plot for 3-Phase Audio Equalizer (High-Pass Testing)

3-Phase Audio Equalizer (Band-Pass Testing)

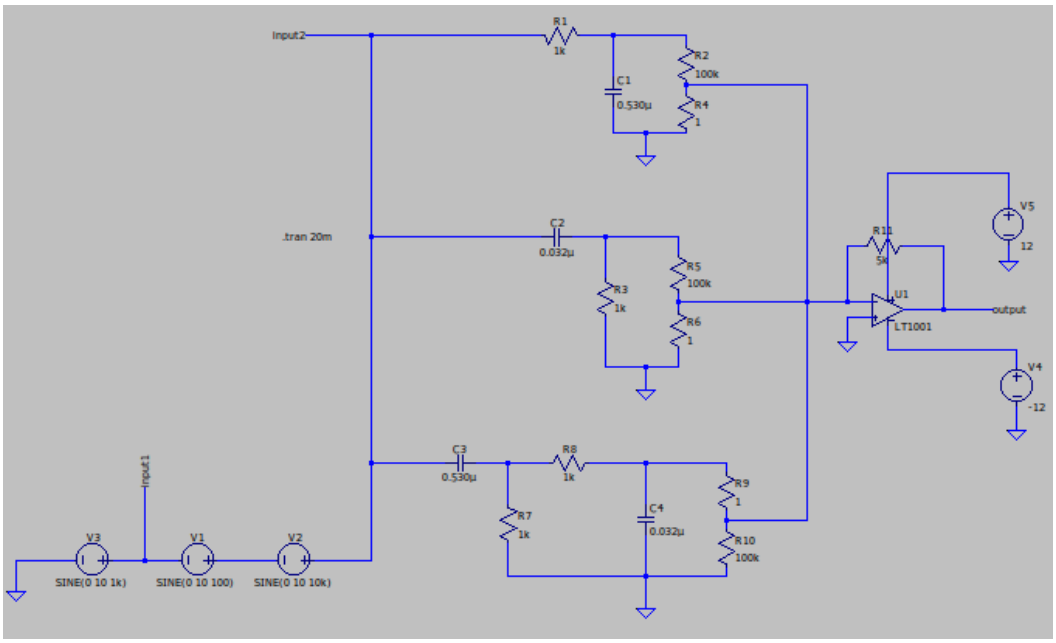

Fig. Transient Analysis Circuit for 3-Phase Audio Equalizer (Band-Pass Testing)

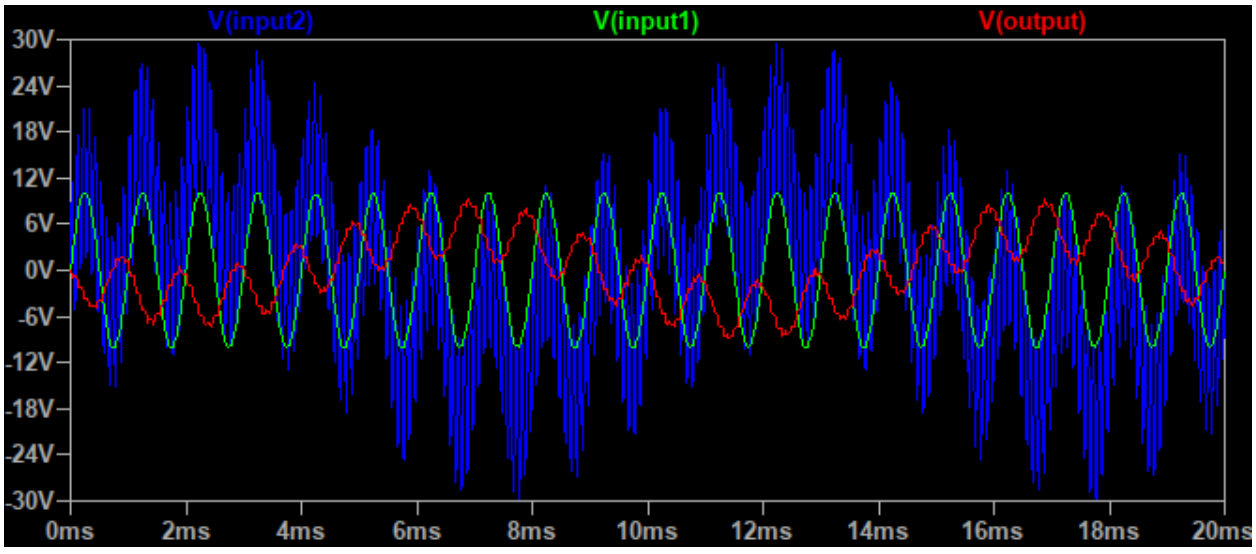

Fig. Transient Analysis Plot for 3-Phase Audio Equalizer (Band-Pass Testing)

USES & HISTORY

Applications

Equalisers have many uses which include but not limited to:

- In sound recording, equalization is used to modify an instrument's sound or make certain instruments and sounds more prominent.
- Equalizers can correct problems posed by a room's acoustics, as an auditorium will generally have an uneven frequency response especially due to standing waves and acoustic dampening.
- Correcting the frequency response of a sound system so that the frequency balance of the music as heard through speakers better matches the original performance picked up by a microphone.
- An equalizer can be used to correct or modify the frequency response of a speaker system rather than designing the speaker itself to have the desired response.
- In tone controls by manipulating bass and treble to improve quality of sound.
- Reducing white noises while recording sound.

Improvements Over Time

The concept of equalization was first applied in correcting the frequency response of telephone lines using passive networks. It was used to correct the uneven frequency response of an electric system by applying a filter having the opposite response, thus restoring the fidelity of the transmission.

The concept was applied in audio engineering to adjust the frequency response in live sound reinforcement systems. Sound engineers correct the frequency response of a sound system so that the frequency balance of the music as heard through speakers better matches the original performance picked up by a microphone.

Graphic equalizers and other equipment developed for improving fidelity have since been used by recording engineers to modify frequency responses for aesthetic reasons.

Present Day – Other similar designs appeared soon thereafter like the Parametric Equalizer. Most channel equalization on mixing consoles rely upon the designs of either semi or fully parametric topology. Parametric equalizers became increasingly available as Digital Signal Processing (DSP) equipment and are typically called Digital Parametric Equalizers.

Future Improvements – With improving technology and innovations, there have been new and emerging approaches to equalization. It focuses on more relevant and intuitive interfaces, often based on machine learning, and on autonomous and intelligent audio equalization systems that attempt to automate aspects of their use.

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