EE4435 Fall 2004

Design Project 2

An Active Crossover Network for a Center Channel Woofer and Two Satellite Speakers with Stereo Separation Enhancement

Object

The object of the project is to design a circuit which will derive a center channel bass output signal and left and right mid and high frequency output signals from a stereo signal pair. In addition, the circuit is to include stereo enhancement which cross feeds out of phase signals from each channel into the other channel.

Background

A satellite loudspeaker system is one which has a center-channel woofer which radiates the bass for both channels and left and right satellite speakers that radiate the mid and high frequencies for the left and right channels. Three separate channels of power amplification are used to drive the three loudspeakers. An electronic circuit is used to sum the left and right signals and low-pass filter the sum for the center-channel amplifier. The circuit high-pass filters the left and right signals for the amplifiers that drive the satellite speakers. The object of this project is to design the electronic circuit which derives the three signals for the power amplifiers. The circuit is to have a stereo enhancement feature which cross feeds part of the left and right signals out of phase into the opposite channel. This method is commonly used to increase the perceived "separation" in a stereo signal. For example, it is found on many stereo television sets.

Specifications

- The circuit is to have two signal inputs called the left in L_{in} and the right in R_{in}.
- The circuit is to have three signal outputs called the left out L_{out}, the center out C_{out}, and the right out R_{out}.
- The circuit is to derive the primed signals given by

$$L'_{in} = \frac{L_{in} - 0.25R_{in}}{0.75}$$

$$R'_{in} = \frac{R_{in} - 0.25L_{in}}{0.75}$$

- The L_{out} signal is be the L'_{in} signal high-pass filtered by a unity-gain, single-pole filter having a pole frequency of 600 Hz.
- The R_{out} signal is be the R'_{in} signal high-pass filtered by a unity-gain, single-pole filter having a pole frequency of 600 Hz.
- The C_{out} signal is to be $-(L'_{in} + R'_{in})$ low pass filtered by a unity-gain, two-pole filter having pole frequencies of 300 Hz and 600 Hz.

- Each input resistance is to be $10\,\mathrm{k}\Omega$.
- Each output resistance is to be $1\,\mathrm{k}\Omega$.
- The dc offset at each output is to be less than $10\,\mathrm{mV}$.
- As part of the project, you are to show that $L_{in} = R_{in} = V_i$ results in $|L_{out} + C_{out} + R_{out}| = |V_i|$. That is, the sum transfer function for the three outputs exhibits unity gain at all frequencies. To do this, you must prove that the sum transfer function is in the form of an all-pass filter.