Elimination of Microphone - Speaker Positive Feedback Phenomenon in Audio Amplifiers

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Abstract: Echo cancellation in communication system is an important task for having high quality audio and video signals. Positive feedback phenomenon in audio amplifiers is one of the most considerable problems which can be considered as the worst case of echo in which all output signals reflected to input signal. An efficient and fast method for canceling such signal by using a figurative duct which simulated reflected signal and eliminated it from input. The parameter of the duct is adjusted with a single frequency code signal. As the code signal has is an ultrasonic frequency, there is no conflict between the test signal and audio signal in the system.

Keywords: Echo cancellation, Audio amplifier, Positive feedback

1 Introduction

Acoustic echoes arise in many systems which involve remote transmission. The echoes can influence the quality of the video and audio transmission. Researchers try to removal or suppress echoes in video and audio signals. They try to do this task by hardware or software or proper combination of both [1-4]. In the following we review some of these efforts.

J. M. Cioffi and M. HO, analyze the block gradient or block least mean square (LMS) algorithm's finite precision performance in the data driven echo canceller application. They show this method significantly needs less precision than standard LMS algorithm. Their algorithm has more convergence and tracking speed [5].

Q. C. Liu et al, proposed fast affine projection (FAP) algorithm as a new adaptive filtering algorithm which is as complexity as LMS but convergence like recursive least square [6].

M. Ho et al, use discrete multitone modulation (DMT) system to proposed a high speed echo cancellation method for full duplex data transmission. They claim these technique can achieve much lower complexity than LMS algorithm [7].

W. C. Chew and B. F. Boroujeny, use new implementation of the LMS/Newton algorithm as the adaptive algorithm to adjust the tap weights of the adaptive filter. They assume the input sequence to the adaptive filter can be modeled as an autoregressive process whose order may be kept much lower than the adaptive filter length [8].

M. Fozunbal et al, proposed a decision making framework which enables a unified approach to detecting the changes in the echo path. They use a new approaches based on the generalized likelihood ratio test [9].

Perhaps you have heard a harsh whistle sound from audio system in formal meetings or seminars. The cause of this phenomenon is the effect of positive feedback in audio system. This is the worst case of echo, in which the signals from speaker receive to microphone directly.

Figure1 shows the block of such system. In the figure $Mic(s)$, $B(s)$ are the transfer function of microphone and speaker, respectively. K is the gain of amplifier whereas, a and T_d are the gain and the delay time of the air channel, respectively. Most amplifier producer companies use weak microphones for preventing of this phenomenon. This restricts the distance of source sound to microphone to some centimeters.

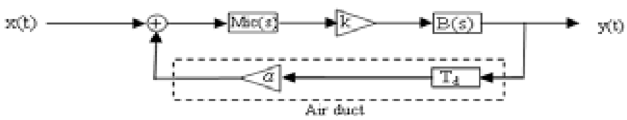

Figure1. Block diagram of positive feedback in a sound system

2 Problem formulations

Echo cancellation between speaker and microphone in real time need a fast algorithm. It means the time domain analysis is preferred. First step in rejecting the echo from signal is finding the distance between microphone and the reflection place. Second step is calculating the attenuation coefficient of the echo path. We use a test signal with frequency higher than audio able sound. Putting a filter exactly after the microphone can separate the test and audio signal. The phase difference between sending and receiving signal is the time which reflect the distance from echo point to microphone. Figure 2 shows the configuration of proposed method. There are three paths: a forward path between microphone and speaker, the second path, named air duct, which models the echo or positive feedback of the signal to the microphone and third path which compensated the echo is called figurative duct. Figurative duct blocks should be similar to air duct and amplifier blocks. Information related to microphone and speaker are presented by producer companies and thus help to producing B'(s) and Mic'(s) blocks. For complete echo or positive cancellation T'_d and a' have to be exactly the same as a and T_d.

The output of figurative duct is 180^0 out of phase with direct signal.

The output signal from microphone is:

$$P(s) = \left(W(s)B(s)a\,e^{-s t_d} + X(s)\right)Mic(s) \qquad (1)$$

The signal in feedback path is:

$$P'(s) = -W(s)B'(s)a'\,Mic'(s)e^{-s t'_d} \qquad (2)$$

If $a' = a$ and $t_d = t'_d$, then we have:

$$W(s) = k\left(P(s) + P'(s)\right) = k\,X(s)Mic(s) \qquad (3)$$

The output is

$$Y(s) = W(s)B(s) = X(s)Mic(s)B(s) \qquad (4)$$

As equation 4 shows, with proposed model the output will not have any way to input and the positive feedback phenomenon which is the worst case of echo never occur.

3 Experimental results

Figure 3 shows recording signal which is an audio signal, equivalent to one, two, three (in Persian language).

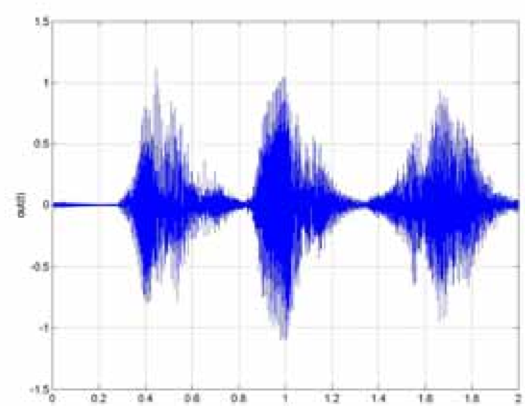

Figure 3. Audio signal , equivalent to one, two , three (in Persian language).

It is recorded by a PC sound card with 44 kHz frequency, 16 bit accuracy, in 2 seconds with MATLAB 6.5 software.

Figure 4 shows only 0.12 of the first second of amplifier output with gain constant 10 that is situated in duct with T_d = 1466 μsec delay (nearly equivalent to 5m distance between speaker and microphone) and a = 0.5 (damping factor in air duct) and x(t) is it's input. Where as the figurative duct is out off service.

The positive feedback effect could be seen clearly (notice the amplitude that how the output toward infinitely).

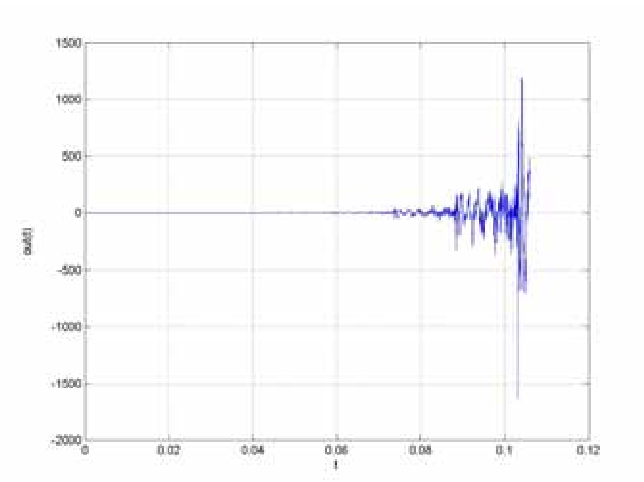

Figure 4. Positive feedback

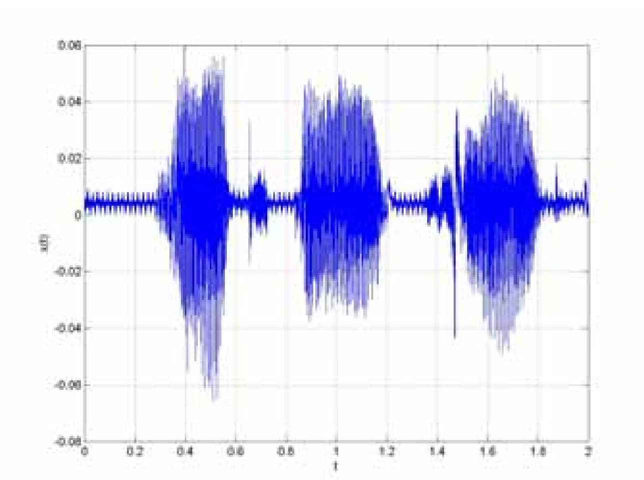

Figure 5. Output of the system with configurative duct

Figure 5 shows the output of the system when the figurative is connected. Calculating the parameters of figurative duct is critical point in this work. We assume that

1) Amplifier and microphone transform function has been modeled well.
2) Amplifier acts as an low pass filter.

4 Conclusions

As the result shows in presented modeling, the echo or positive feedback can be removed. The sensitivity of microphone can be increase without decreasing the quality of sound system. In addition if microphone is moved and can observe the speaker, the feedback removes completely and the system works well.

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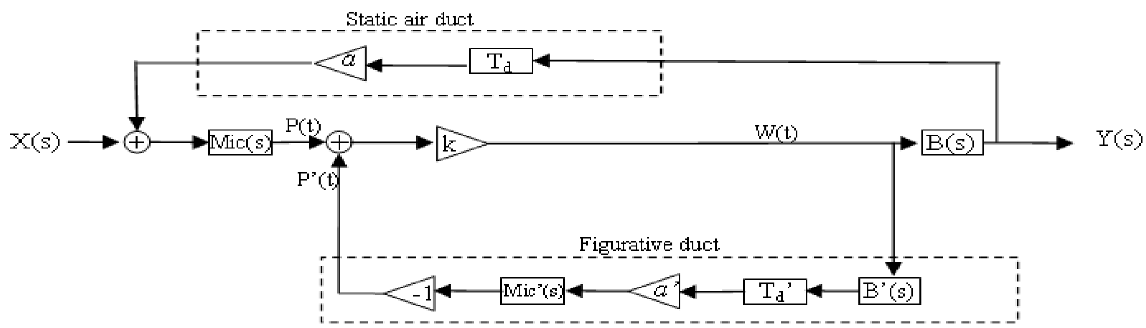

Figure 2. Block of control system