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Analysis of Noise Cancellation Using ANR System

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Abstract— ***ANR is noise reduction system that is used to reduce the noise pollution in two ways, active and passive. Active noise control uses power to reduce the noise whereas the passive noise reduction uses the noise isolating material such as insulation, etc. Active noise reduction is used for low frequencies and passive can be used for all frequencies. Active Noise Reduction is the based on superimposed principle that is, we will use the opposite of same amplitude by secondary source so as to reduce the noise. In recent past various adaptive algorithms were developed for noise reduction. In this paper we use some particular technique like internal model control (IMC) in which error signal and adaptive filter output is used which is filtered by secondary path output. High dB noise is harmful for human ears and is unbearable specifically by patients and children. Therefore, in this paper ANR system based on IMC technique is applied on ambulance siren. The simulations are performed on MATLAB shows that noise gets suppressed up to 37 dB, which is a considerable reduction to siren noise.***

Keywords— ***Acoustic noise, Adaptive feedback filter, ANR, path modeling.***

I. INTRODUCTION

With the massive use of industrial equipment Acoustic noise problems has become a burning issue. It is generally influential in vehicular systems, electrical apparatus, manufacturing plants, medical machinery system and human activities. The medical research has proved that listening to high level sound for too long, but the human life at the risk of high blood pressure, hearing loss, headache, fatigue, stress, anxiety and loss of concentration which results in reduced productivity. A machinery system also produces another type of noise called mechanical vibration which present in almost all transportation systems and home appliances. [1, 2].

Earlier passive noise control was the base for acoustic noise reduction techniques, such as barriers, enclosures, silencers, earplugs, and sound-absorbing materials. These passive techniques are effective for reducing noise over a wide frequency range. It requires large & costly materials and are ineffective at low frequencies. This is the reason for adaptation of the active noise reduction (ANR) in last decade, which has gained rigorous development to reduce low-frequency noise. [3-5]. ANR is an electro-acoustical technique based on the superposition principles, that is, an anti-noise with the same amplitude but opposite phase is generated by secondary source(s) to cancel unwanted noise acoustically, thus resulting in reduced residual noise. The performance of noise reduction is mainly dependent on the correctness of the amplitude and phase of the anti-noise generated by a signal processing algorithm. We use adaptive filter to analyze time variations. As we can see in figure 1 how we are utilizing finite impulse response (FIR) filter with least mean square (LMS) algorithm through common adaptive filter. Off-line secondary path leads to implement active noise reduction system. Practically, it is required to estimate the secondary path by online method with the help of ANR system[5].

For the purpose of emergency, ambulance siren creates a loud noise which is very infuriating for human beings as well as for patients. But only the solution of this problem is anti- noise scheme. It is necessary to reduce noise pollution for ambulance patient. There are two techniques to decrease noise pollution, passive and active. Active techniques are more reliable as compared to passive techniques. So, for the safety of patient Active Noise Reduction (ANR) system [2] will be deployed in the ambulance to cancel the noise pollution. Practically we are not able to completely get rid of noise problem. The remaining residual noise can be eliminated by using Adaptive filter.

II. TRADITIONAL ANR SYSTEM

By using Filtered-x Least Mean Square (FxLMS) [6, 7] in ANR system as depicted in fig.1, it will filter input signal by secondary path of ANR system.

As we can see in fig.1 P(z) is representing primary path between two microphones i.e. reference microphone and error microphone. Whereas, W(z) represents Adaptive filter. In-order to vary and adjust weights of filter for effective reduction of noise, we use Least mean square algorithm (LMS), it uses filtered x as input through secondary path of ANR system, therefore, it is called Filtered-x Least Mean Square (FxLMS) algorithm. In order to minimize error signal *e(n)* of error microphone we update and adjust Weights.

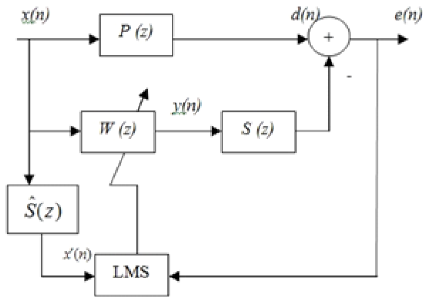

Fig 1:- FxLMS based ANR system.

S(z) represent secondary path impulse response, it considers the D/A converter, power amplifier, path followed by noise from the loudspeaker to error microphone, secondary loudspeaker, error microphone, preamplifier, anti-aliasing filter, smoothing filter, and A/D converter [8, 9]. $\hat{S}(z)$ is the estimation of secondary path. This estimate of secondary path is considered as a time variable for practical applications, so as to capture this time varying effect online model of secondary path is used. x(n) represents primary noise signal at reference microphone.

e(n) represents error signal calculated by:

$$e(n)= d(n)-y'(n),$$

where d(n)=p(n)*x(n);

$$y'(n) = s(n) * y(n) \text{ and } y(n)=w(n)*x(n).$$

Weights of adaptive filter w(n) are updated by using below equation.

$$w(n+1) = w(n) + \mu \, x'(n)e(n) \qquad (1)$$

the step size of the w(n) filter is μ ; $x'(n) = \hat{s}(n) * x(n)$.

III. SIMULATION RESULTS

This paper describes ANR system based on IMC technique is applied on ambulance siren noise. Simulation for the same are performed using MATLAB 2012 software. Figure 2 depicts the reference noise signal i.e. noise taken from ambulance siren. Now, reference noise signal would be applied to ANR system for the purpose of reducing noise to make the comfortable era for patient. During first stage of simulation primary path transfer function P(z) and secondary path transfer function S(z) are measured for experiment and weights of H(z) is taken zero. The length of each, Primary path P(z), secondary path S(z) and H(z) have taken 128 long. We use step size μ_w=0 .05, μ_h =0.03 and μ_s=0.006 to update coefficient of adaptive filter.

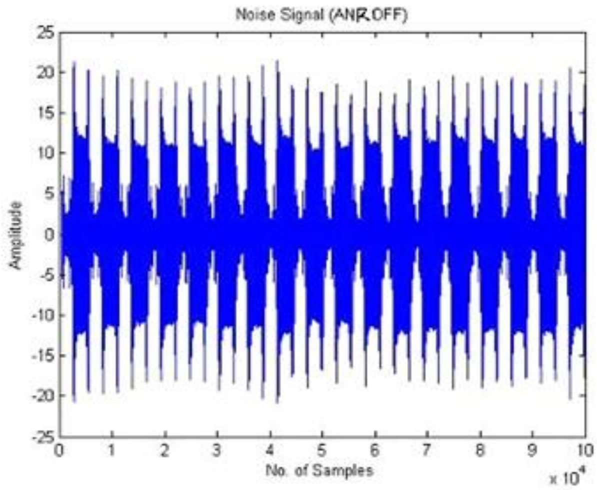

Fig 2:- The Ambulance Siren Signal taken as reference noise signal (ANR OFF)

The figure 3 depicts the residual noise signal on usage of active noise reduction with online secondary path modeled by cross updated filters. The conclusion of figure 2 and 3 shows the reduction of ambulance siren noise successfully by ANR system i.e. results in pleasant and tranquil zone for patient. To measure the effective result of noise reduction, we calculate SNR (signal to noise ratio) of the reference noise and the residual noise at the side of error microphone. The equation (2) is used to find SNR for this system:

$$SNR = 10\log_{10}\left(\frac{\sum e^2(n)(ANC\_OFF)}{\sum e^2(n)(ANC\_ON)}\right) \qquad (2)$$

The result of SNR indicates reduction in noise pollution of ambulance upto 37 dB approximate.

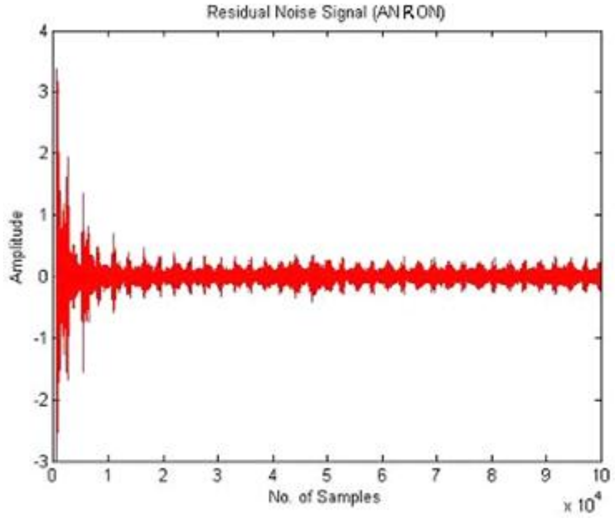

Fig 3:- The residual noise signal (ANR with secondary path modeling is ON)

The Power spectral Density (PSD) describes the distribution of signal power within the given frequency. We can see the PSD of reference ambulance siren noise signal in figure 4(a) and PSD of residual noise signal after applying ANR in figure 4(b). ANR with online secondary path modeling gives the effective and significant result.

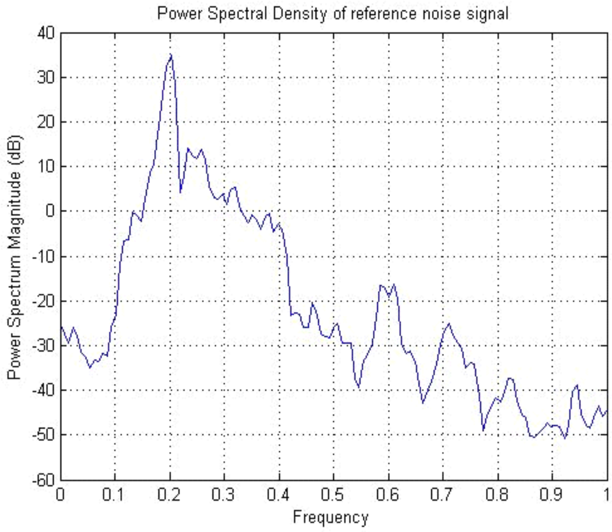

Fig 4(a):- Power spectral Density for reference noise signal of the ambulance siren noise (ANR OFF)

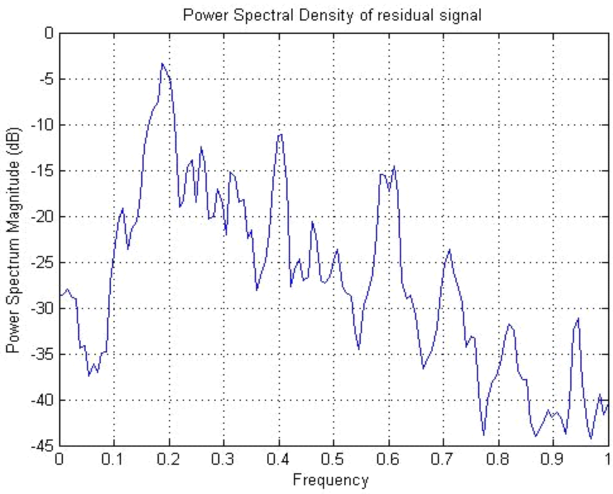

Fig 4(b):- Power spectral Density for residual noise signal (ANR ON)

The ANR performance has been applied on the ambulance siren noise after some experiment by updating weight and parameter, μ_w. The performance after some experiment can be generalized using smoothened ensemble average square error (SEASE), $\xi_{sd}(n)$ [10]. This is calculated according to equations (3)-(5).

$$\xi_{sd}(n) = 10\log_{10}(\xi_S(n)), \quad (3)$$

$$\xi_S(n) = \lambda\xi_S(n-1) + (1-\lambda)\xi(n), \quad 0<\lambda<1, \quad (4)$$

$$\xi(n) = \frac{1}{K}\sum_{i=1}^{K} e_i^{\,2}(n). \quad (5)$$

Where K factor represents number of realizations $e_i(n)$ represents error for ith realization.

The plot of SEASE with respect to number of samples is shown in Fig. 5.

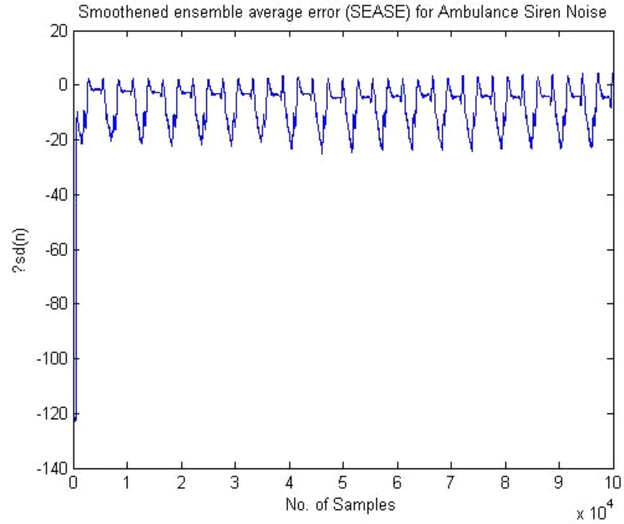

Fig. 5 Plot of SEASE for ANR with online secondary path modeling to ambulance siren noise.

IV. CONCLUSION

Noise pollution, as we know it is getting honking situation i.e. affecting life of every individual. The way it affects the lifestyle of every individual is by hampering the productivity as it directly affects the ability to concentrate. Not only this, it leads to several other consequences like hearing problem, anxiety and most importantly it severely affects the life of children and patients. Therefore, it becomes important to suppress noise pollution by use of all means available. For example, ambulance that is most required means of transport for carrying patients but every ambulance do use siren for alerting the traffic in-order to get a clear passage. But the siren causes a lot discomfort and irate the patient and at times the medical team as well. Not only this it does also, effect the communication between the patient and medical attendant/team.

Therefore, we can use ANR system for reducing the noise of ambulance siren. In this paper, ANR with internal model control technique (IMC) is used to reduce the noise pollution caused by ambulance siren so that there can be decline in the above mentioned situations. The simulations are performed on MATLAB. By using this technique the noise can be reduced up to 37 dB. Hence, ANR with IMC technique is an efficient method of curbing noise pollution and it is not only limited to ambulance siren, this can be used with many more applications. The power spectral density response of ANR ON and ANR OFF depicts that ambulance noise reduction is an important application of ANR system for the well being of patient and medical team in ambulance.

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