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MEASUREMENT AND CONTROL OF NOISE POLLUTION IN ROAD-TRAFFIC SYSTEM USING AUDIO FREQUENCY WAVE ANALYSER

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Abstract: A theoretical study has been carried out to find the application of audio-frequency wave analyser to detect sounds and vibrations produced as noise by different types of vehicles, like-Motor-cycles, Buses, Trucks, Cars, etc. in road-traffic system and to analyse these sound signals to find the amplitudes of them in dBA at tunned frequencies of audio frequency range of 20 Hz to 20 KHz. Studies have also been carried out to find the ways and means to reduce the amplitudes of noise sources by the methods of isolation, adsorbtion, damping etc.

1. INTRODUCTION

Like air and water pollution, control of noise pollution has also been given due importance for the last many years [1, 2, 3]. Transportation is another major source of noise in addition to variety of noises such as-domestic noise, air-craft noise, construction noise and industrial noise, all leading to discomfort to human being. Noise level, above 120 dBA causes not only irritations but also several types of health hazards to human being. Road-traffic noise is produced due to sound and vibrations generated by buses, cars, motor-cycles trucks, etc. moving at high speeds.

The audio frequency wave analyser can be used to detect the sound signal of different types of vehicles at the road-traffic junctions in the form of complex wave form and to analyse this signal to find its different components of noise sources at their tunned frequencies. Once these sources of sound are detected, the ways and meaks to reduce their amplitudes, can be found out.

In this paper, and attempt has been made to present the methods of measuring sounds and vibrations generated by different types of vehicles used in road-traffic system, and ways and means to reduce their amplitudes so that they will be noise free.

2. INSTRUMENTATION SYSTEM AND METHOD

2.1. Instrumentation System for Noise Measurement and Analysis

An audio frequency wave analyser can be used in the frequency range of 20Hz to 20KHz to measure the sound and wave generated by the road-traffic vehicles. It is an instrument designed to measure relative amplitudes of single frequency components of a complex wave form.

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Basically, this instrument act as a frequency selective voltmeter which is tunned to frequency of one signal and rejecting all the signal components. The desired frequency is selected by a frequency calibrated did to the point of maximum amplitude. The amplitude is indicated either by a suitable voltmeter or CRO.

In a road-traffic system, the complex, noise signal may consists noise of motor-cycles, cars, heavy-tracks, buses, etc generally, these noise sources will have different amplitudes and frequencies. Mathematically, this complex noise signal can be express as—

$$f(t) = A_1 \text{ Sin } (\omega_1 t + \varphi_1) + A_2 \text{ Sin } (\omega_2 t + \varphi_2) + A_3 \text{ Sin } (\omega_3 t + \varphi_3) \quad (1)$$

Where, A_1, A_2, A_3 = Amplitudes of noise of Motor-cycles, cars, buses etc in dBA.

$\omega_1, \omega_2, \omega_3$ = Frequencies of noise components in radian/sec.

$\varphi_1, \varphi_2, \varphi_3$ = Phase angles of noise components in radian.

The block diagram model of an audio frequency wave analyser suitable for road-traffic noise measurement is shown in Figure 1.

The complex wave form to be analysed, in terms of its separate frequency components, is applied to an input attenuator that is set by the meter range switch on the front panel. A driver amplifier feeds the attenuated wave form of a cascade arrangement of RC resonant section and filter amplifiers. The pass band stop of total filter section is covered in decade over the entire audio frequency range (20 Hz to 20KHz) by switching capacitors in RC sections. Close-tolerence polystyrene capacitors are generally used for selecting frequency ranges. Precision potentiometers are used to tune to filter to any desired frequency within the selected pass band. A final amplifier stage supplies the selected signal to the meter circuit and to untunned buffer amplifier. The buffer amplifier can be used to drive a recorder or an electronic counter. The meter is driven by average type detectors and has a several voltage ranges as well as a decibel (dB) scale. The band width of the instrument is very narrow; typically about 1 per cent the selected frequency.

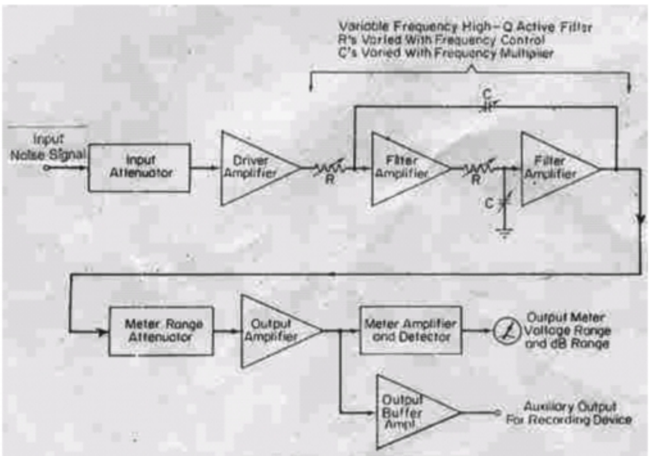

Figure 1: Schmatic Diagram of an Audio-Frequency Wave Analyzer

2.2. Sources of Road-traffic Noise and Vibration, and Ways and Means to Reduce them Once the Source of Noise in a Road-traffic System are Defected by the Audio-frequency Wave Analyser, Ways and Means can be Found Out to Reduce them at the Tolerable Limit

The vibrations play a significant role in generation as well as transmission of noise. The vibration of transmitters and radiators lead to origin of noise in road transportation system, the vehicles, which generally produce noise are Motor-cycles, cars, trucks, buses, etc. The mechanical vibrations are usually responsible for generation of noise in them. Such vibrations are caused by forces which vary with time. These forces may be rotational, translational, rolling or sliding. They may be associated with either electrical, mechanical, hydraulic or aerodynamic operations. In India, motorcycles are the worst culprits, wherein the noise originates from exhaust and engine. It can produce 110 to 120 dBA noise. A car gives 60dBA, a bus 80dBA, while a heavy truck at high speed produces noise at the level of 100 to 110dBA. These noises are bounded on hard surfaces of the buildings and are reflected back to the ears. Lisualy, noise is produced by air turbulence around bodywork of a moving car, a truck etc. Tyres are an usual sources of noise specially on cement, roads, if they are travelling at high speed. Horns blown at high amplitude by the vehicles also cause noise pollution in the environment.

After detecting and analyzing the nature and sources of noise pollution in road-transportation systems the reduction of the amplitudes of them can be done by adopting following steps:

(i) Periodic maintenance to remove broken or defective parts and oiling and greasing and brushing joining parts.

(ii) Use of silencers.

(iii) Use of damping element to reduce vibration.

(iv) Mufflers can be used in Motor-cycle, Mopeds, Scooter to reduce noise.

(v) Trees and bushes are to be planted on highways to reduce noise by dispersing it on leaves and branches.

(vi) Use of automatic control systems.

(vii) Strict regulations and laws which can be implemented by Government to control noise pollution.

3. RESULTS AND DISCUSSIONS

From the description of the instrumentation system and methods, of the previous section and the investigation reports it can be shown that the noise and vibration associated with mechanical structures of the vehicles usually involves one of the two situation as illustrated in Figure 2 (a) and Figure 2(b).

The first type of vibration problem deals with a system that has one or more internal excitation sources, S_p as shown Figure 2 (a). The sources are usually characterized by measuring the structural response at some point Q on the external surface of the structure or machine with an accelerometer.

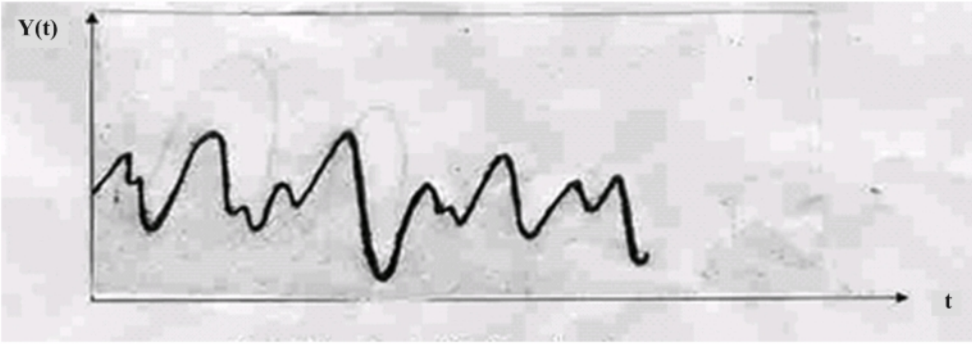

Figure 2: Noise Signal, y(t) in Time Domain

The second type of problem involves a known excitation force F_p (t), which is applied at a location P on the external surface of the system. A response X_Q (t) is measured at some exterior point Q as indicated in Figure 2 (b). in both situations, the frequency response function $H_{QP}(\omega)$ for the structural system controls the magnititude and phase of the output signal recorded at point Q.

The output signal a(t) in Figure 2(a) results from the combined effects of the vibration source S_p and their respective frequency response functions H(ω). Furthermore, the various frequency response functions depend on the design of the structure, the location of the source and location of the mass of the transducer. The transducer's frequency response also influences the output signal. If a transducer is moved, all of the frequency responses change. At certain frequencies, vibration will disappear at some locations. Thus, transducer location influences the output signal.

A typical response signal, recorded with a transducer is shown in Figure 3 (a). Such traces are extremely complex. However, when the are properly analyzed, they can provide much useful information relating to the vibrational characteristics of the system. Response signals f(t) are typically analyzed in two domains: the time domain and the frequency domain.

In the time domain, single value descriptions of the typical complex noise signal is shown in Figure 3(a).

In the frequency domain, the data of the f(t) signal are represented as a function of frequency ω. This representation is shown in Figure 3(b).

It gives the amplitudes of the various components of the noise signal in dBA as a function of the excitation frequency ω in Hz and known as the frequency spectrum.

From the Figure 3(a), it can be seen that the peaks ω_a, ω_b, ω_c, ω_d and so on are related to the noises of Motor-cycles, cars, Trucks, Buses and the like. It is evident that a frequency spectrum is more useful, because if indicates discrete frequencies that are related to operating characteristics of the different noise-sources. It can also be seen that the amplitudes of noises of the different sources in the road-transportation system are in descending order of

Motor-cycle > Heavy truck > Bus > Car

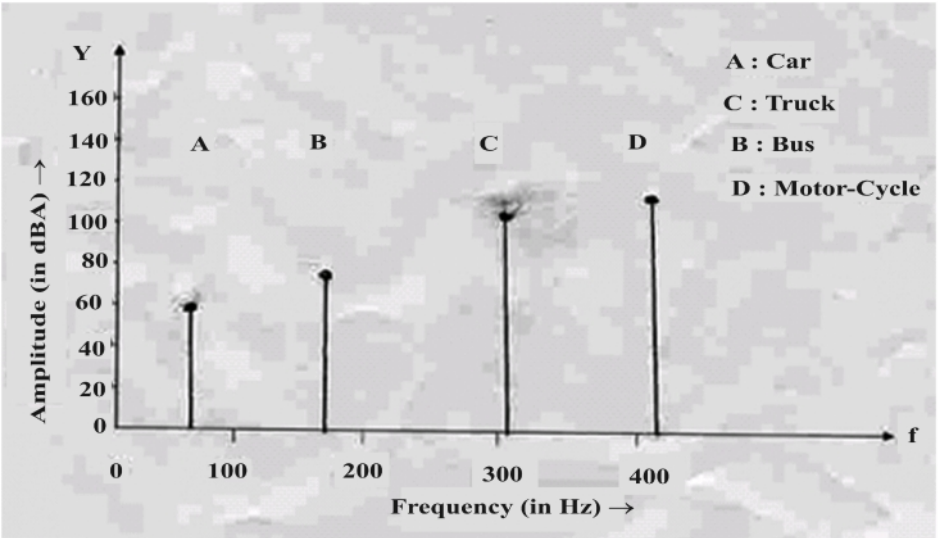

Figure 3: Frequency Spectrum of Signal y (t)

In order to reduce the noise in road-traffic system, we will have to eliminate the vibrations very much at the sources. Such vibrating system has source, path and a surface. These vibrations can be easily eliminated by isolation, adsorption and damping.

4. CONLCUSION

The method, analysis and results presented in this paper are based on the theoretical studies. The actual analysis and results need the application of the instrumentation system used in practice and to perform necessary experiments in the road-traffic system to verify theoretical results. This instrumentation system could be used to detect and analyse to noises produced by various types aero-planes in air-traffic system and also for different types of machines and apparatus used in various industries and hence to find the ways and means to reduce noise.

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