Control of Noise Pollution by Sound Limiters

1. Introduction :

In today's chaotic world noise pollution is a prevalent issue. According to the Central Pollution Control Board, Government of India, "the increasing ambient noise levels in public places from various sources, inter-alia, industrial activity, construction activity, generator sets, loud speakers, public address systems, music systems, vehicular horns and other mechanical devices have deleterious effects on human health and the psychological well being of the people." This highlights that excessive noise from machines, road and air traffic, indiscriminate use of public address systems at parties & other gatherings, etc. can cause what is called "Noise Pollution", namely unwanted sound levels which have many harmful effects on humans, animals and the environment. In the short run, noise pollution causes stress and makes it difficult for people to study, sleep, or concentrate on whatever they are doing. In the long term, prolonged exposure can cause serious hearing problems, psychological issues and sleep irregularities.

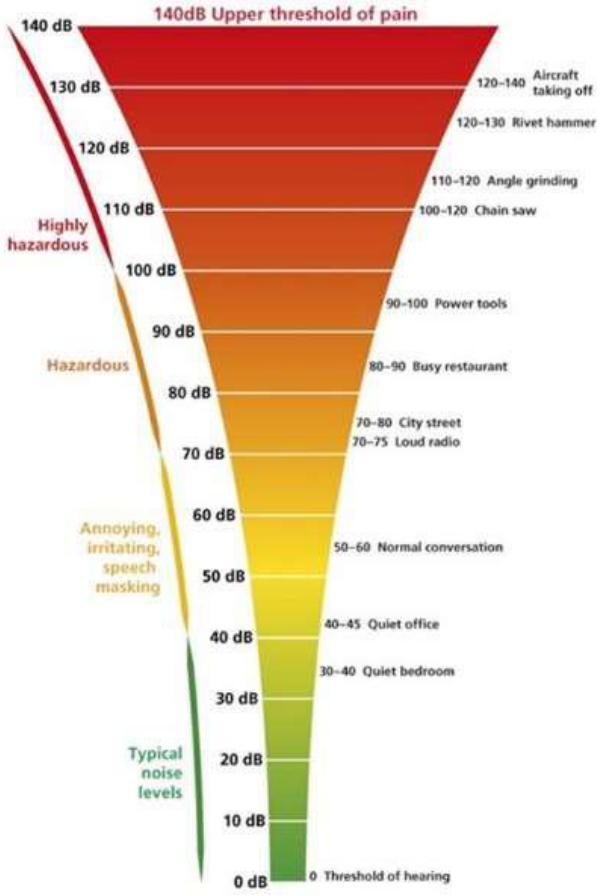
Traffic and irresponsible use of public address systems are major noise polluters in India, and are increasingly becoming areas of serious concern. Outdoor public meetings and outdoor marriage functions are very common in India. Parties and marriage functions in India almost always involve loud music and dancing, often at outdoor locations. Also, music played at indoor parties very often is disturbingly audible outside, becoming a nuisance to neighbors who wish to study, sleep or carry on other tasks. Such parties are almost always held in the late evening and carry on into the night, which results in their disturbing effect becoming even more serious. This flagrant violation of civic sense is usually not intentional, but happens because the persons causing the nuisance are so engrossed in their own enjoyment that they do not realize how much nuisance they are causing.

I will focus here on noise pollution due to public address systems. The term "public address system" will include amplifiers and loudspeakers of all types, along with their associated equipment like microphones, mixers etc. Of course, public address systems are useful and even necessary for emergency evacuation, airport / railway station announcements, paging and many other applications. However, indiscriminate use of public address systems without civic sense becomes a public nuisance, and this needs to be controlled. I will examine how control can be achieved automatically by using a simple device known as "noise limiter". The purpose of the noise limiter is to ensure that the sound created by the public address system is limited in loudness such that it does not reach disturbing levels outside the premises being used for the gathering, and does not become a nuisance to people outside.

I studied and evaluated two types of noise limiters, which are described later (attenuating type & cut-off type), and made a prototype with the help of some engineers.

2. Disturbing Noise Levels :

I have used the chart below to put the sound pressure levels emitted by loudspeakers into perspective. This is from the Institution of Occupational Safety & Health, UK :



The chart above clearly shows that any sound pressure level (SPL) above 70 DB is hazardous and above 100 DB is highly hazardous. In fact even exposure to SPLs of 50 db can be irritating, and can prevent a person from sleeping or concentrating on his work.

To understand the various sound levels produced by speakers of different wattages, I studied a 200 watt, 400 watt and 1000 watt speaker from different brands. A 200 watt speaker produces a SPL of 100 db at 1 metre when operating at 1 watt. Since the SPL decreases by 6 db for every doubling of distance, the following formula can be used to calculate the SPL at different distances (D). If the SPL at 1 metre = S_1 and the SPL at distance D = S_2:

$S_2 = S_1 - 6(\text{Log}_2 D)$

Since every doubling of power increases the SPL by 3 db, and every reduction in power alters the SPL by -3db, the undermentioned formula can be used to calculate the SPL at power (P). The SPL at 1 watt = S_1 and SPL at P watts = S_2:

$S_2 = S_1 + 3(\text{Log}_2 P)$

200 Watt Speaker (SPL)	1 metre	2 metres	4 metres	8 metres	16 metres	32 metres
Operating at 1 watt	100 DB	94 DB	88 DB	82 DB	76 DB	70 DB
Operating at 10 watts	110 DB	104 DB	98 DB	92 DB	86 DB	80 DB
Operating at 100 watts	120 DB	114 DB	108 DB	102 DB	96 DB	90 DB
Operating at 200 watts (Full Capacity)	123 DB	117 DB	111 DB	105 DB	99 DB	93 DB

500 Watt Speaker (SPL)	1 metre	2 metres	4 metres	8 metres	16 metres	32 metres
Operating at 1 watt	101 DB	95 DB	89 DB	83 DB	77 DB	71 DB
Operating at 10 watts	111 DB	105 DB	99 DB	93 DB	87 DB	81 DB
Operating at 100 watts	121 DB	115 DB	109 DB	103 DB	97 DB	91 DB
Operating at 500 watts (Full Capacity)	128 DB	122 DB	116 DB	110 DB	104 DB	98 DB

1000 Watt Speaker (SPL)	1 metre	2 metres	4 metres	8 metres	16 metres	32 metres
Operating at 1 watt	102 DB	96 DB	90 DB	84 DB	78 DB	72 DB
Operating at 10 watts	112 DB	106 DB	100 DB	94 DB	88 DB	82 DB
Operating at 100 watts	122DB	116 DB	110 DB	104 DB	98 DB	92 DB
Operating at 1000 watts (Full Capacity)	132 DB	126 DB	120 DB	114 DB	108 DB	102 DB

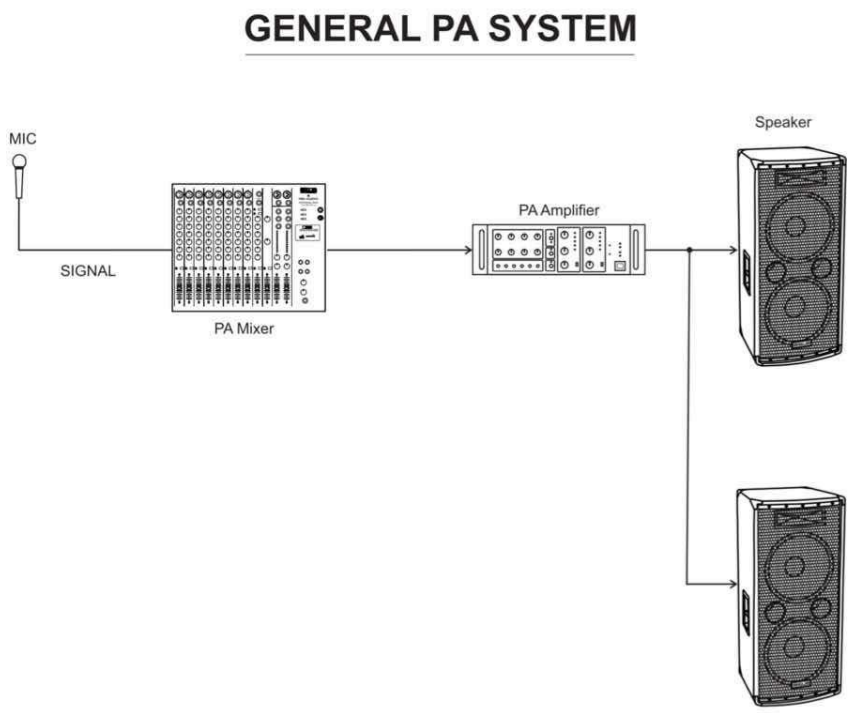
All these figure are much louder than a city street and can be very disturbing. Most of these SPLs are louder than the sound produced by a chain saw and are categorised as ‘ Highly Hazardous’.

It is therefore clear that unrestricted use of high power amplifiers / loudspeakers at outdoor venues is a very bad practice. Use of such high power public address systems even inside houses / bars / restaurants can be objectionable unless extensive soundproofing of the building has been done.

P.T.O

3. Public Address System :

A typical public address system consists of a microphone (sound input), a mixer, an amplifier and speakers. This system's job is to boost the sound pressure level (loudness) of its input sound. The block diagram below shows the components of a PA system.

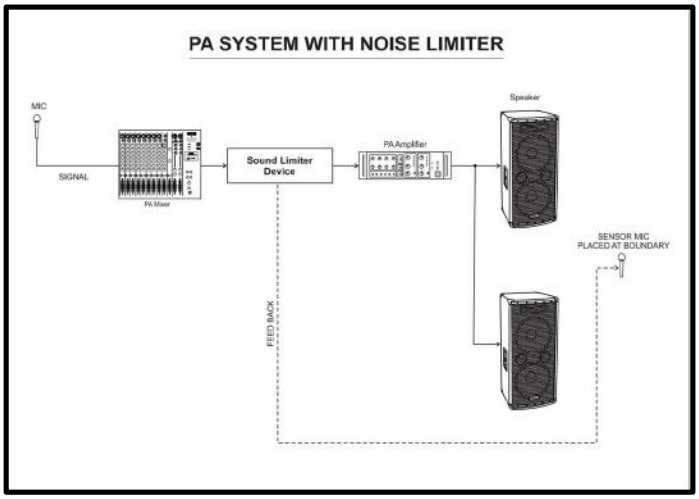


In this system, the microphone senses the sound and coverts the sound vibrations into an electrical signal. This electrical signal is then passed through the mixer, which combines sound from different sources. The amplifier boosts the voltage and current of the electrical signal and passes this high power signal to the speakers. A speaker's function is exactly opposite that of a microphone. The speakers at the end of the PA system convert the boosted electrical signal back to sound. Therefore this sound produced at the end of this system is much louder than the sound input through the microphone.

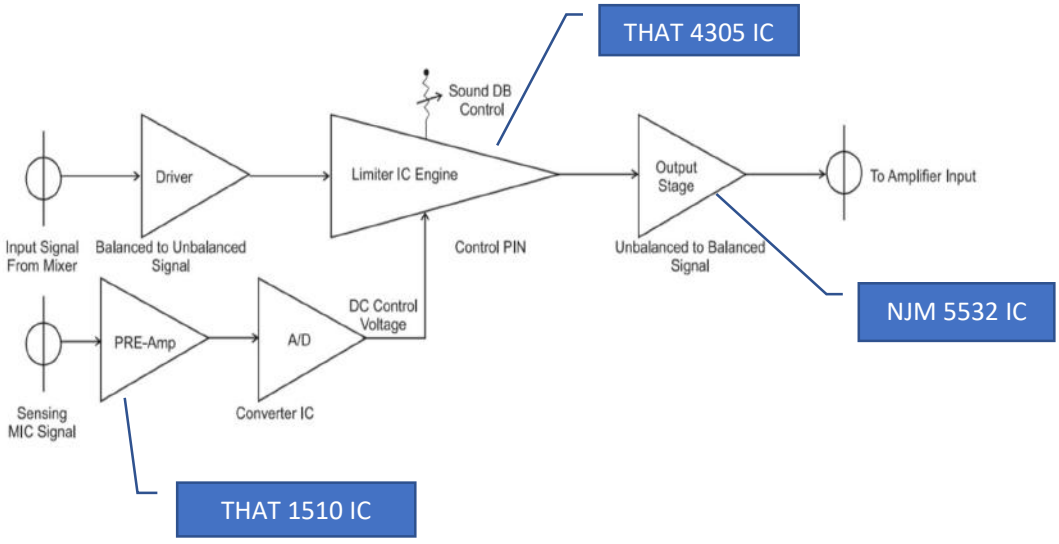
While looking for a solution to the noise pollution produced by PA systems, I came across a device called the Noise Limiter. A Noise Limiter's job is to control the SPL produced by a PA system as suggested by the name.

4. Attenuating Type Noise Limiter – Principles :

The block diagram below shows a PA system with the attenuating type Noise Limiter.



The noise limiter shown here is an attenuating one. An attenuating sound limiter is attached between the mixer and amplifier. The microphone attached to the limiter senses the SPL produced by the PA system and sends a feedback signal to the limiter. This microphone can be placed at the boundary of the private property where the program is being held. The purpose is to monitor the sound level leaking out from the property and causing a public nuisance outside. Depending on this feedback signal, the limiter regulates and decreases the voltage passed on to the amplifier so as to decrease the SPL produced by the system. For example, if the limit on the sound limiter is set to 80 db and the microphone detects an SPL of 90 db, the limiter will automatically reduce the input to the amplifier in such a way as to reduce the SPL produced by the loudspeakers by 10 db. This will avoid unacceptably high sound levels from leaking out of the program venue and disturbing the people living or working nearby. The block diagram below shows the working of this type of a limiter.



BLOCK DIAGRAM OF ATTENUATING TYPE NOSE LIMITER

The heart of the Noise Limiter is the IC 4305 from THAT Corp, USA. This is a single chip audio engine optimised for applications like compressors, limiters and AGC.

The signal from the mixer is first converted from balanced to unbalanced, then fed into the main limiter IC 4305. The signal from the monitoring microphone is first pre-amplified in an IC (THAT 1510), then converted to digital, rectified to DC, and fed into the limiter IC 4305. The mixer signal going into 4305 is suitably attenuated depending on the level of microphone signal being received by the 4305. If the monitoring microphone picks up a high signal, the 1510 gives a higher output, and the mixer signal is more attenuated in the 4305. On the other hand, if the monitoring microphone picks up a lower signal, the output from the 1510 is accordingly lower, and the attenuation of the mixer signal in the 4305 is appropriately lower. Finally, the output of the limiter IC 4305 is passed through an output stage (IC NJM 5532) which also converts the signal once more into a balanced signal for travelling through a cable to the amplifier.

5. Attenuating Type Noise Limiter (Evaluation of Sample) :

The assembled Noise Limiter was evaluated using both music and sine wave signals. The performance was functionally satisfactory with music, but specific readings were difficult to take because the music signal is a continuously changing signal. Sine wave testing was then used to enable specific and exact readings. Three different frequencies were used : 500Hz, 1KHz and 5KHz. The signal was taken from a sine wave generator, passed through a mixer and amplifier, and then to a high wattage loudspeaker. A monitoring microphone was kept in front of the loudspeaker, and I checked the effectiveness of the limiter, i.e signal level at the location of the monitoring microphone with and without the limiter. This way I measured to what extent the limiter was able to control the output of the PA system to stay within the set SPL limit.

Limiter was set to maximum effectiveness. (In principle, a control could be given on the Limiter to adjust its effectiveness and obtain any set decibel level ; however, this was not done. I used only two settings : No Limiter action and full Limiter action.

FREQUENCY (Hz)	SPL without Limiter (db)	SPL with Limiter (db)
500	85	71
500	90	76
500	95	77
500	100	82
1000	85	69
1000	90	72
1000	95	76
1000	100	79
5000	85	67
5000	90	73
5000	95	74
5000	100	81

Music comprises a continuously changing set of frequencies. I therefore took the average reading, i.e average of 500/1000/5000Hz for 85 db level ; similarly average reading for the three different frequencies at 90, 95 and 100 db levels. The results which emerge are as follows :

SPL without Limiter (av. of 3 frequencies)	SPL with Limiter (av. of 3 frequencies)	Attenuation Achieved
85 db	69 db	16 db
90 db	73.6 db	16.4 db
95 db	75.6 db	19.4 db
100 db	80.6 db	19.4 db

This shows that the Limiter, at its full capability, was capable of controlling the sound level (at the boundary of a user's premises) to about 75 db or any value higher than this. An attenuation of approximately 20 db was achieved at the more objectionable higher SPL levels of 95 and 100db.

If 75 db is maintained at the outer boundary of a user's property, I would expect that the level inside any neighbouring house or office would be much less than this, and would not be disturbing. In any case, the 75 db level would be much less of a hazard than the 90 or 95 db which the PA system was giving at the same location without a limiter.

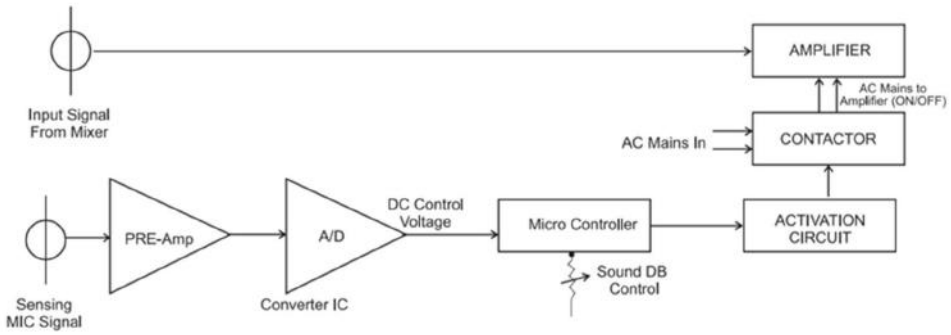
SPL With Limiter

SPL Without Limiter



6. Cut-off Type Noise Limiter :

There is another type of Sound Limiter which is much easier, namely the Cut-off Type. In this case, the amplifier gets its power supply through an AC mains socket on the Limiter. The Sound Limiter is set to allow a certain limit, for example 80 db. If the microphone connected to the limiter (and placed at the boundary of the premises) senses an SPL more than 80 db, it cuts off the power supply to the amplifier and shuts the system down temporarily. A cut off limiter is placed between the amplifier and power supply, so that the moment the limit SPL is exceeded, the power supply is cut off. The block diagram below shows this type of a limiter in detail.



BLOCK DIAGRAM OF CUT-OFF TYPE NOISE

7. Other Types of Noise Limiter :

There can be other types of Noise Limiters also. For example, instead of automatically attenuating or cutting off the signal, the Limiter may give a visual indication of the sound level leaking out of the premises through Green (acceptable), Yellow (borderline) and Red (unacceptable) LEDs.

8. Sound Limiters :

Sound Limiters are sometimes used in a PA system (or built inside a mixer or amplifier) to prevent clipping of the audio waveform. If a user attempts to raise the level of a signal beyond the equipment's ability to reproduce faithfully (without distortion), the limiter automatically attenuates or compresses the signal. These sound limiters are not covered in this project, as the focus here is to reduce noise pollution.