

DIRECTIONAL SOUND SYSTEM

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Abstract – A Directional Sound System is a device which allows sound waves to pass only in one direction. Directional sound system works entirely different than conventional sound system or Loudspeaker. The main difference between conventional sound system and Directional sound system is that Directional sound system utilizes modulation of Acoustic sound waves and Ultrasound waves. This paper aims at explanation of working, principle, and illustration of Directional Sound System.

Key Words: Directional Sound, Ultrasound, Modulation, Demodulation, Sound Waves.

1. INTRODUCTION

Directional Sound System is a device capable of transmitting sound in any particular direction over a wide range. A conventional sound system spreads sound waves over a wide area as it consists of plastic cone that reciprocates and transmit sound in a wide arc. The output of a conventional speaker is directly proportional to the input in form of electrical current which means the more energy feed into the speaker, the more energy it can pump out as sound. Where a directional sound system works entirely different than conventional speakers. Directional sound system utilizes ultrasound waves for transmission of sound.

An ultrasound is inaudible sound frequency for human beings ranging higher than 20000Hz. Where human audible frequency or an acoustic sound frequency ranges from 20Hz to 20000Hz. Audible and Ultrasound frequencies are shown in Fig – 1. Ultrasound waves are highly directional which means ultrasound can travel in one direction without diffraction. Directional sound system encodes audible sound frequency by modulating it over ultrasonic sound waves. By this way Directional sound system can deliver narrow beam of sound with desired audible frequency to particular area while preserving silence around it, or allowing co-existence of different sounds in a same space without mixing or interfering. Directional sound system can deliver highly directional distribution of sound. The sound with high quality with low noise and great frequency response can also be delivered using Directional sound system. Specific and controlled distribution of sound waves will eventually result in reduction of noise pollution and Directional sound system will play major role in the field of engineering.

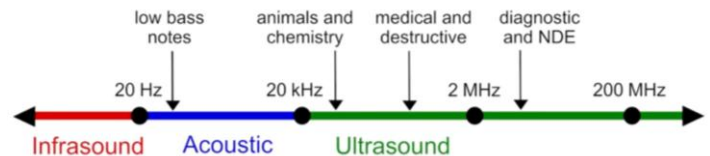


Fig – 1: Sound frequency scale

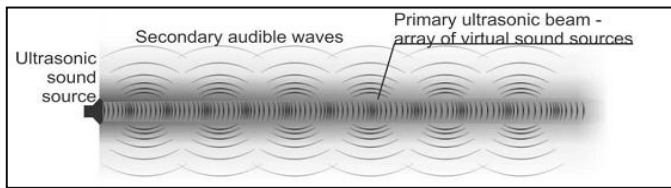
1.1 Working of a Directional Sound System.

Directional Sound System utilizes principle of Parametric Acoustic Arrays (PAA). The audible sound frequency or an input signal is first mixed through Ultrasound frequency this process of combining two frequencies of different wavelength is known as modulation. For modulation ultrasonic sound frequency is selected as carrier because of its short wavelength and high frequency characteristics which means ultrasound waves are less diffractive. Modulated sound frequency travels out from Directional Sound System in form of narrow beam. Thus Directional Sound System can transmit sound over long distance.

The ultrasonic sound waves act as a carrier for audible sound frequency and when frequency and amplitude is high enough air itself becomes a non-linear medium which act as a demodulator, and audible frequency is delivered to the receiver. Which means when modulated frequency from Directional sound system hits someone or receiver the demodulation of frequency occurs that is ultrasonic sound waves and audible input signal separates and input signal or audible frequency is delivered to receiver.

A parametric acoustic array (PAA) is generated by emitting an intense and highly directed ultrasonic beam consisting of a carrier wave and signal components introduced by modulation technique. The carrier interacts with other spectral components of the ultrasonic beam due to the nonlinearity of air at high acoustic sound pressure levels (SPL) and generates new spectral components along the ultrasonic beam. These secondary waves contain audible spectral components or audible signal output related to the difference between the carrier and side bands. The nonlinearity of air also generates higher inaudible frequencies which are quickly absorbed due to the high absorption coefficient at high frequencies. Thus the ultrasonic source creates a beam of ultrasound which acts as a virtual array of sound sources. Fig – 2 shows output Parametric acoustic array generated by Directional Sound System.

Fig – 2: Output PAA of Directional Sound System



1.2 Modulation and Demodulation of Sound Frequency

Modulation of frequency or Frequency Modulation (FM) is the process of encoding of input signal wave in a carrier wave by varying the instantaneous frequency of the wave. In Directional sound system audible sound frequency is encoded in ultrasonic sound wave which act as a carrier. This phenomenon of frequency modulation is also used in FM radio. Modulation of sound waves in Directional Sound System is shown in Fig – 3.

Demodulation is process of extracting input signal or audible frequency from modulated frequency which in case of Directional Sound System is receiver and air act as a medium for this process.

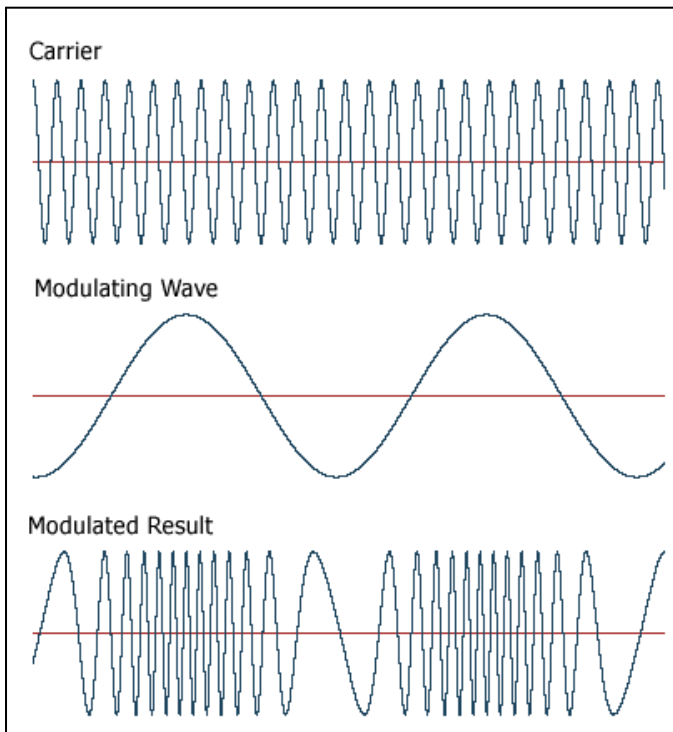


Fig – 3: Modulation of Frequency

2. Need of a Directional Sound System.

Giant sound systems are used in variety of places for example music festival these systems produce large amount of sound energy that they can be heard over wide area, weather you want to hear them or not. Similarly, conventional sound systems for example speaker, loudspeaker have same fatal flaw which indeed creates social disturbance. Directional Sound System can be a revolutionary in terms of sound consumption. Major advantage of directional sound system is that they can control the range of output audio signal. As shown in Fig – 4 using Directional sound system it will be possible to control sound output over limited area and range. Most of the time this is exactly how we want sound system to work, but there are times that it would be helpful if they are more selective in terms of receiver or listener. For example, you want to play some music at night without disturbing anyone else in your house. Wouldn't it be neat if only you could listen to music on speaker without disturbing anyone else? This is exactly how directional sound system works. It can be described as an audio LASER that can travel over wide distance and can be focused over the precise area. Directional Sound System would be a single major entity that can reduce noise pollution in near future.

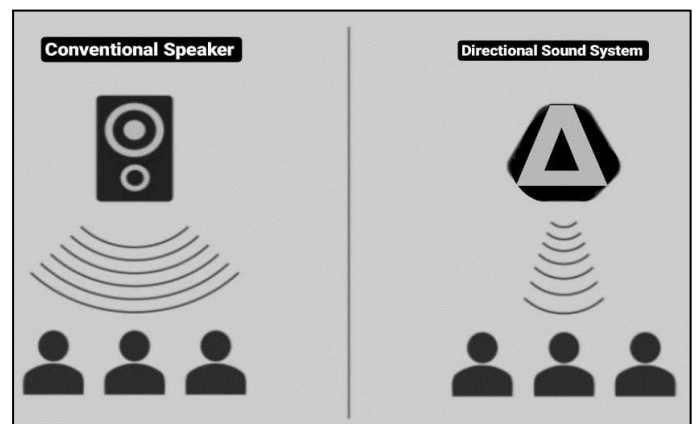


Fig – 4: Conventional Vs Directional sound systems.

3. Illustration of Directional Sound System.

To build Directional sound system important components is Ultrasonic sound waves. Ultrasonic sound waves in air are usually generated by Piezoelectric transducers. These piezoelectric transducers are made up of crystal structures such as quartz, which vibrates back and forth thousand time per second when electric current is passed through them, producing high frequency ultrasonic sound. The active element of piezoelectric transducer is thin disc made up of Lead Zirconate Titanate (PZT) ceramics. Applied voltage cause a disc to expand and contract. Thus center of this PZT disc displaced depending upon polarity of the voltage. The mechanical and physical dimensions of this disc determines the resonant frequency and bandwidth of the transducer.

Individual ultrasonic speakers have low very low output therefore, combining multiple small ultrasonic speakers will generate efficient amount of ultrasonic sound that can be used for modulation. The main functional units of illustrated Directional Sound Systems are as follows:

- High pass filter.
- Standard 555 Timer.
- Amplifier and signal conditioner.
- Ultrasonic Speakers.
- 12V power supply with 5V regulator.

3.1 Architecture Diagram

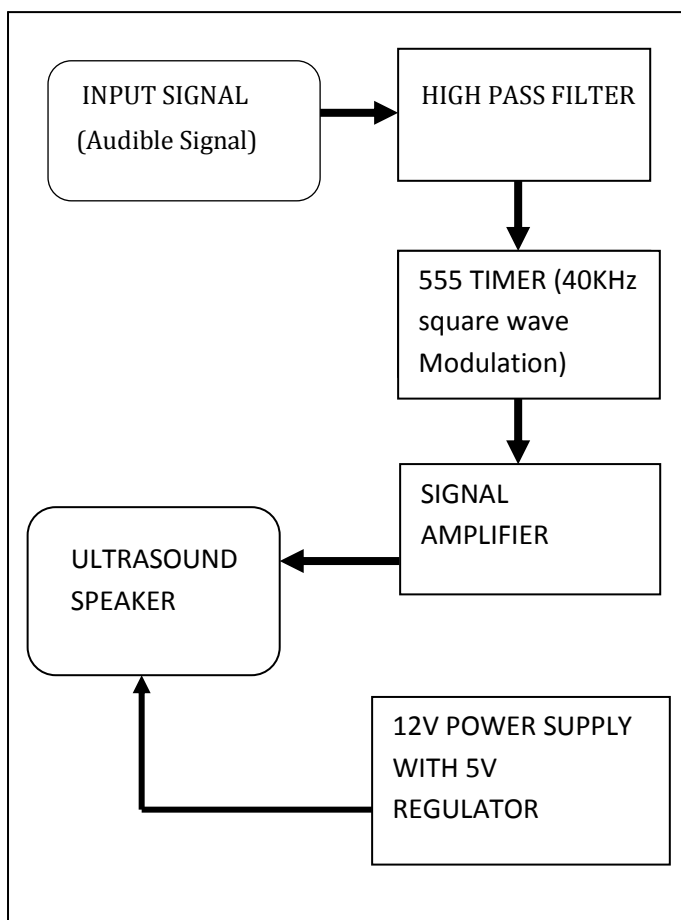


Chart - 1: Architecture of Directional Sound System.

As shown in Chart -1 the input signal that is audible sound frequency is passed through high pass filter which passes signals with a frequency higher than a certain cutoff frequency and attenuates signals with frequencies lower than the cutoff frequency it also reduces the DC offset from input signal. That filtered signal travels through standard 555 Timer circuit to modulate 40KHz square wave frequency. Then signal passes through amplifier to drive ultrasound speaker. This ultrasound speaker is powered by 12V battery supply and connected to 5V regulator for logic controls. This way input audible signal is modulated with high ultrasonic frequency as a carrier and transmitted through ultrasound

speaker as an output. Fig - 5 shows the Circuit diagram of Directional sound system.

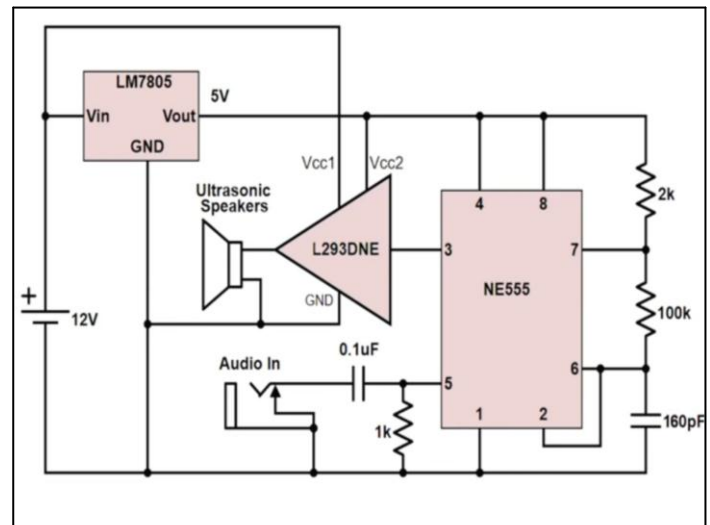


Fig - 5: Circuit Diagram of Directional Sound System.

4. CONCLUSIONS

Directional Sound System is very first example of high end sound modulation. There is still much room for scientific development and research. Although lot of efforts are made to improve quality and efficiency of parametric arrays (PAA). Different type of systems utilizes similar principle of Directional Sound System. For example, LRAD (Long Range Acoustic Device) is developed by US Military, it is Directional Sound System equipped with high end technology. The paper discusses working principle and example of Directional Sound System in form of illustrated design, further it gives background on modulation techniques used for Directional Sound Systems. It serves as thorough reference for researchers and engineers and will also be an introduction to those who are less familiar with the subject.

REFERENCES

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