Audio Spotlighting

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Abstract- Audio spot lighting is a revolutionary new audio technology that creates focused beams of sound similar to light beams coming out of a flashlight. By 'shining' sound to one location, specific listeners can be targeted with sound without others nearby hearing it. It uses a non-linear acoustics for its working. This acoustic device comprises a speaker that fires inaudible ultrasound pulses with very small wavelength which act in a manner very similar to that of a narrow column. The ultra sound beam acts as an air borne speaker and as the beam moves through the air gradual distortion takes place in a predictable way due to the property of non-linearity of air. This gives rise to audible components that can be accurately predicted and precisely controlled. Audio Spotlight that is made of a sound processor, an amplifier and the transducer. Audio spotlight can be either directed at a particular listener or to a point where it is reflected.

I. INTRODUCTION

Audio Spotlight is a narrow beam of sound that can be controlled with similar precision to light from a spotlight. It uses a beam of ultrasound as a "virtual acoustic source", enabling control of sound distribution. The ultrasound has wavelengths only a few millimeters long which are much smaller than the source, and therefore naturally travel in an extremely narrow beam. The ultrasound, which contains frequencies far outside the range of human hearing, is completely inaudible. But as the ultrasonic beam travels through the air, the inherent properties of the air cause the ultrasound to change shape in a predictable way. This gives rise to frequency components in the audible band, which can be predicted and controlled.

The targeted or directed audio technology is going to a huge commercial market in entertainment and consumer electronics and technology developers are scrambling to tap into the market. Being the most recent and drastic change in the way we perceive sound since the invention of coil loud speaker, audio spotlight technology can do many miracles in various fields like private messaging system, home theaters etc. Thus audio spotlighting helps us to control where sound comes from and where it goes.

II. HISTORY

This technology was originally developed by the US Navy and Soviet Navy for underwater sonar in the mid-1960s. In 1975, the first publication appeared which demonstrated that these nonlinear effects indeed occur in air. While these researchers had not attempted to reproduce audio, also they nonetheless proved that such a device can be possible.

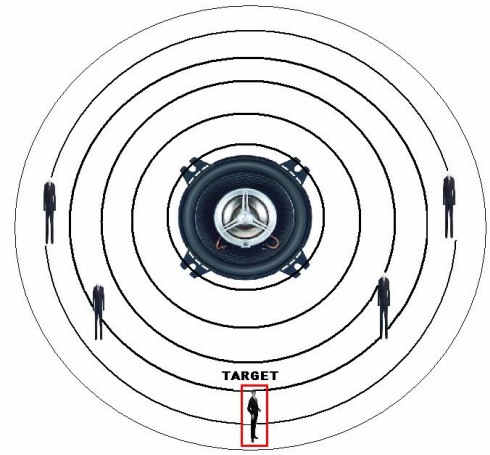
The technology was briefly investigated by Japanese researchers in the early 1980s, but these efforts were abandoned due to extremely poor sound quality (high distortion) and substantial system cost.

These problems went unsolved until a paper published by Dr. F. Joseph Pompei of the Massachusetts Institute of Technology in 1998 fully described a working device that reduced audible distortion essentially to that of a traditional loudspeaker.

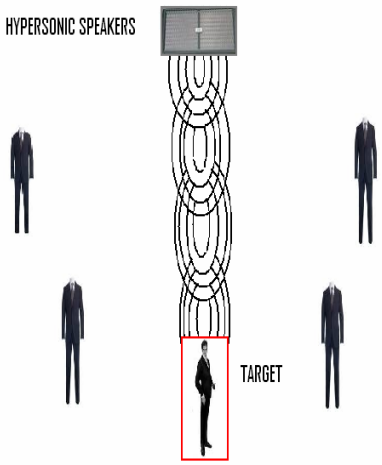
III. THEORY

About half a dozen commonly used speaker types are in general use today. They range from piezoelectric tweeters that recreate the high end of the audio spectrum, to various kinds of mid-ranges speakers and woofers that produce the lower frequencies. Even the most sophisticated hi-fi speakers have difficult time in reproducing clean bass, and generally rely on a large woofer/enclosure combination to assist in the task. Whether they be dynamic, electrostatic, or some other transducer-based design, all loudspeakers today have one thing in common : they are direct radiating, i.e., they are fundamentally a piston-like device designed to directly pump air molecules into motion to create the audible sound we hear. The audible portions of sound tend to spread out in all directions from the point of origin. They do not travel as narrow beams-that is why you don't need to be right

in front of a radio to hear music. In fact, the beam angle of audible sound is very wide, just about 360 degrees. This effectively means the sound that you hear will be propagated through air equally in all directions.



Conventional Speaker

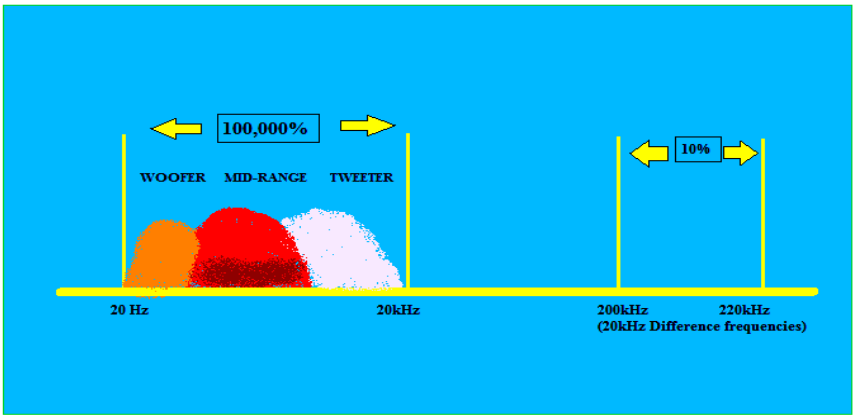


Audio Spotlighting system

In order to focus sound into narrow beam, you need to maintain a low beam angle that is dictated by wavelength. The smaller is the wavelength, the less is the beam angle, and hence, the more focused is the sound. Unfortunately, most of the human audible sound is a mixture of signals with varying wavelengths that is between 2 cm to 17 cm (the human hearing ranges from a frequency of 20Hz to 20,000 Hz). Hence, except for very low wavelengths, just about entire audible spectrum tends to spread out at 360 degrees. To create narrow sound beam, the aperture size of the source also matters a large loud speaker will focus sound over the smaller areas. If the source loudspeaker can be made several times larger than the wavelength of the sound transmitted, then the finely focused beam can be created. The problem here is that this not a very practical solution.

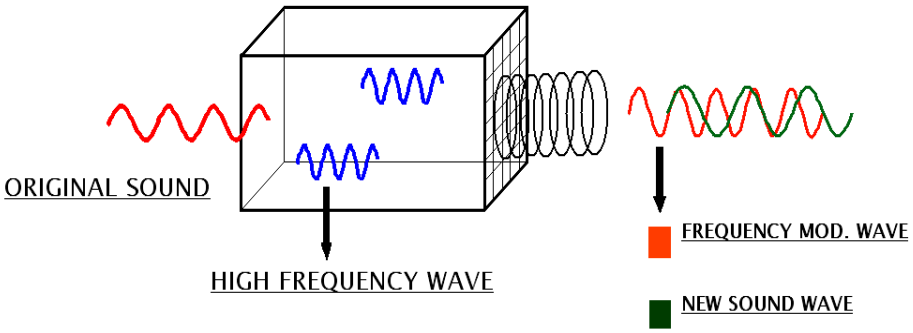
IV. WORKING

As we know human audible frequency range is 20 Hz to 20 kHz. In this system originally the low frequency sound such as human voice or music is transformed into a high frequency ultrasonic sound which inaudible for human.



Showing the Difference in Modulating Audible Frequencies with Ultrasonic Carrier.

In the beginning the human voice or music is applied to the audio spotlight emitter device. The low frequency data is modulated to a high frequency ultrasonic level. Since the wave length of the ultrasonic frequency is small of the order of mm and beam angle is also small hence the sound beam will be narrow with small dispersion. When inaudible ultrasound pulses are fired into the air, it spontaneously converts the inaudible ultrasound into the audible sound tones, hence proved that as like water, sound propagation in air is non-linear.

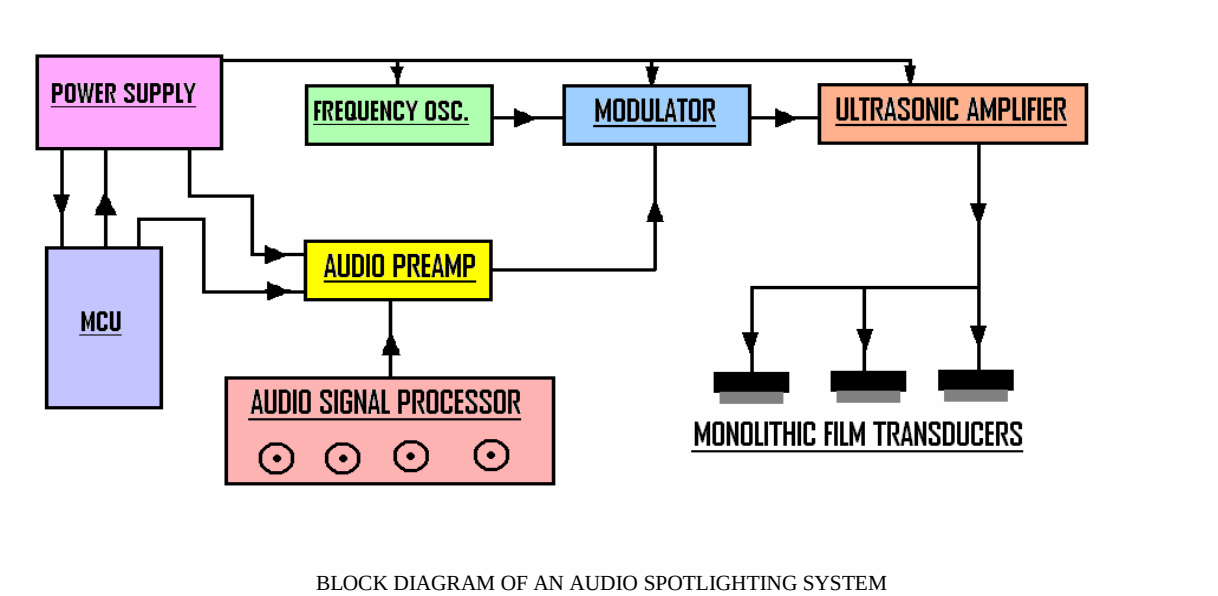


Audio spotlighting emitter

So due to its non-linear property the air slightly alters the sound wave, the alteration in the original sound wave gives rise to a new sound wave within the ultrasonic wave. The new sound signal generated within ultrasonic wave will be corresponding to the original information signal with human audible frequency range. Since we can't hear the ultrasonic sound wave we hear only new sound wave which is formed due to the non-linearity of air.

V. COMPONENTS OF AUDIO SPOTLIGHTING

1. Power supply.
2. Frequency oscillator.
3. Modulator.
4. Audio signal processor.
5. Microcontroller unit.
6. Ultrasonic amplifier.
7. Transducer.



BLOCK DIAGRAM OF AN AUDIO SPOTLIGHTING SYSTEM

1. **Power supply:** Like all electronics the audio spotlight works off the DC supply. Ultrasonic amplifier requires 48v DC supply for its working and low voltage for microcontroller and other units.

2. **Frequency oscillator:** The frequency oscillator generates ultrasonic frequency of in the range of which is required for the modulation of information signal.
3. **Modulator:** In order to convert the source signal material into ultrasonic signal a modulation scheme is required which is achieved through a modulator. In addition, error correction is needed to reduce distortion without loss of efficiency. By using a DSB modulator the modulation index can be reduced to decrease distortion.
4. **Audio signal processor:** The audio signal is sent to electronic signal processor circuit where equalization and distortion control are performed in order to produce a good quality sound signal.
5. **Microcontroller:** A dedicated microcontroller circuit takes care of the functional management of the system. In the future version, it is expected that the whole process like functional management, signal processing, double side band modulation and even switch mode power supply would be effectively taken care of by a single embedded IC.
6. **Ultrasonic Amplifier:** High-efficiency ultrasonic power amplifiers amplifies the frequency modulated wave in order to match the impedance of the integrated transducers. So that the output of the emitter will be more powerful and can cover more distance.
7. **Transducer:** It is 1.27 cm thick and 17 cm in diameter. It is capable of producing audibility up to 200 meters with better clarity of sound. It has the ability of real time sound reproduction with zero lag. It can be wall, overhead or flush mounted. These transducers are arranged in form of an array called parametric array.

VI. MODES OF LISTENING

There are two types of listening:

1) Direct Mode
2) Projected Mode

1) **Direct Mode:** Direct mode requires a clear line of approach from the sound system unit to the point where the listener can hear the audio. To restrict the audio in a specific area this method is appropriate.
2) **Projected or Virtual mode:** This mode requires an unbroken line of approach from the emitter of audio spotlighting system, so the emitter is pointed at the spot where the sound is to be heard. For this mode of operation the sound beam from an emitter is made to reflect from a reflecting surface such as a wall surface or a diffuser surface. A virtual sound source creates an illusion of sound source that emanates from a surface or direction where no physical loudspeaker is present.

VII. ADVANTAGES

- Can focus sound only at the place you want.
- Ultrasonic emitter devices are thin and flat and do not require a mounting cabinet.
- The focused or directed sound travels much faster in a straight line than conventional loudspeakers.
- Dispersion can be controlled - very narrow or wider to cover more listening area.
- Highly cost effective as the maintenance required is less as compared to conventional loud speakers and have longer life span.

- Requires only same power as required for regular speakers.
- There is no lag in reproducing the sound.

VIII. APPLICATIONS

⇒ Automobiles: Beam alert signals can be directly propagated from an announcement device in the dashboard to the driver. Presently Mercedes – Benz are fitted with audio spotlighting speakers so that individual travellers can enjoy the music of there on interest.

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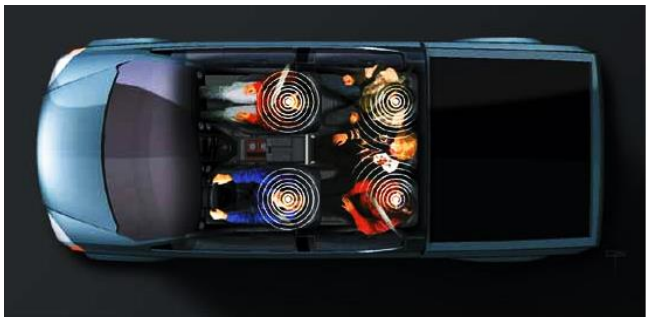


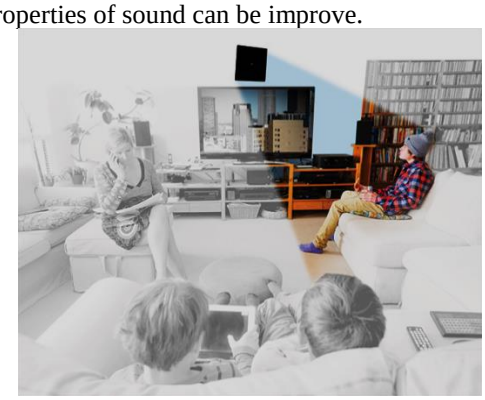
⇒ Store advertisement: Provide targeted advertising directly at the point of purchase.

⇒ Safety officials: Portable audio spotlighting devices for communicating with a specific person in a crowd of people.

⇒ Hospitals: Using the unprecedented directivity of the Audio Spotlight directional speaker technology, patients are able to watch the programs they prefer, privately, without bothering any of the other patients, doctors, or nursing staff.

⇒ Emergency rescue: Rescuers can communicate with endangered people far from reach.

⇒ Entertainment system: In home theatre system rear speakers can be eliminated by the implementation of audio spotlighting and the properties of sound can be improve.



⇒ Museums: In museums audio spotlight can be used to describe about a particular object to a person standing in front it, so that the other person standing in front of another object will not be able to hear the description.

⇒ Military applications: Ship - to - ship communications and shipboard announcements.
⇒ Audio/Video conferencing: Project the audio from a conference in four different languages, forma single central device without the need for headphones.
⇒ Sound bullets: Jack the sound level 50 times the human threshold of pain, and an offshoot of audio spotlighting sound technology becomes a non-lethal weapon.

IX. CONCLUSION

Audio Spotlighting is going to change our view in sound transmission. The user can decide the direction of sound in which it should propagate. Since the sound in this system propagates in single direction, it is applicable in several fields. Audio Spotlighting will be an amazing experience for the users.

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