



HIGHLY FOCUSED ULTRASONIC DEVICE FOR WOMEN SAFETY APPLICATIONS

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Abstract

Sound is one of the most important medium used for delivering information. With rising crime in today's society, especially against women, carrying some sort of effective weapon for self-defense purposes has become quite essential. This technology emits sound in a highly controlled, narrow beam, so that audio can be heard only when you are in the field of beam or in a position to hear the reflected sound from a virtual source. Sound wave in the audible range has a characteristic to spread in various directions while moving, but ultrasound is unidirectional. This characteristic of sound finds applications at a lot of different areas. Parametric loudspeakers can be used in the advertisement industry where audio is considered as a key influence but is abstained from use because the sound being multi-directional spreads and bothers even the people not in target. Usually, in case of a riot, smoke grenades and tear gases are used to control the rioters, which on addition on controlling the target also affect the innocents. This study highlights on using an ultrasonic weapon rather than weapons like hand gun, which can be unsafe and might also initiate legal intrusion. Nowadays MEMS ultrasonic transducers have been put to use which has got very portable design outlet. The study uses the application of ultrasonic beams and sound focusing to build a portable women safety device similar to that of a stun gun.

Keywords: Parametric Loudspeakers; Unidirectional; Ultrasonic Transducer; Weapon; Portable.

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1. Introduction

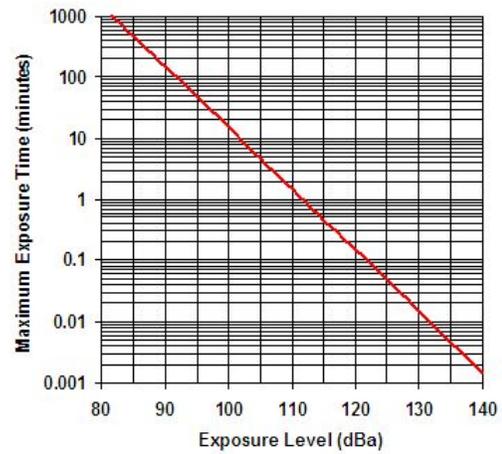
Human beings have capabilities to hear sound from the range of 20 Hz - 20 KHz. The sound range above this level is termed as ultrasonic and the one below it is called infrasonic.

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According to studies a phenomenon called roughness happens when frequency or amplitude of a sound is altered very quickly. When roughness occurs, the ear is no longer able to ‘breakdown’ these temporal changes which are perceived as rough and the sound is usually unbearable by human ear. Sound energy therefore can be used to develop an effective non-lethal weapon, they can be termed as directed energy weapons. Depending on size, it can have up to 15-20ft effective range.

Range	Frequency / Hz	Ear pain	PTS from short exposure	Eardrum rupture	Transient vestibular effects	Respiratory organs
Infrasound	1 - 20	160 .. 140 (1 .. 20 Hz)	none up to 170	>170	none up to 170	none up to 170
Low audio	20 - 250	135 - 140	none up to 150	160	150 mild nausea	150 intolerable sensations
High audio	250 - 8 k	140	120 .. 135 .. 150 1 h .. 7 min .. 0.4 s strongest at 1-4 kHz	160	140 slight equilibrium disturbance	140 tickling in mouth etc. 160 heating
Very high audio/ultrasound	8 k - 20 k / > 20 k	140	none up to 156	?	none up to 154	140 tickling in mouth etc. 160 heating
Blast wave	-	145	150 - 160	185	160	200 lung rupture 210 death



An ultrasonic weapon is a device that emits a high frequency and high energy sound wave that can be pointed at an attacker to cause intense pain and discomfort. Ultrasonic and Infrasonic waves at a power level higher than 120 db can have severe effects on a human body with very less exposure time required i.e. less than ten seconds. The effect includes pressure in the ears, imbalance, vibration of internal organs, visual blurring, nausea, fatigue etc. This study explores the scope of a mini sonic weapon with dimension similar to that of a handgun to be used a self-defense device. When the trigger is pulled, a high- power vicious focused beam of ultrasound will be generated and will numb and neutralize the person who is on the receiving end of it.

2. Materials and Methods

In 1972 France used infrasonic generators which operated at 7 Hz on its population. In the mid-1990s Russia had developed a 10 Hz Very low frequency modulator capable of targeting people over hundreds of meters, causing vomiting, nausea and pain, which was adjustable up to mortal levels. Back in 1997, US DOD had interest in creating these generators in both infrasonic and ultrasonic ranges, which can cause these effects.

Few existing types of sonic devices are discussed below:

- 1) **Audio Spotlight:** The first modern device for air acoustic use was created in 1998 known as audio spotlight named by Japanese researchers. It looks like a disk-shaped loudspeaker and forms a chain of wires with a small laser guide beam mounted in the middle. It is

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based on a principle that Inherent nonlinearity of air acts as a demodulator when a Frequency modulated signal travel through it and the new sound can be heard by eardrums.

- 2) **VR Soundlazer:** It uses planar array to focus sound to specific area. Arrays consist of many tiny transducers which are lined in straight rows on the same surface. The emitted signals from the individual transducer combine to focus a signal to a listener's ears.
- 3) **Vortex Gun:** It produces vortex rings which circulates masses of air and makes it to go on intently to travel over a longer distance. The early tests seem not to be particularly successful but vortex ring guns are still being developed and marketed.
- 4) **LRAD (Long Range Acoustics Devices):** It was developed by American Technology Corporation (ATCO) to send warning tones at longer distance with higher volume. It has power levels of 150 decibels. The piezoelectric transducers are arranged so that they are in phase with each other and resulting sounds they emit can combine to make the projected sound louder. The device weighs around 45 pounds and can emit sound in a 30-60° beam, only at high frequency.

2.1. Need For Women Safety Device?

In the past few years, crimes against women have seen an exponential growth .The twenty-first century which should have seen a world with equality and mutual safety is witnessing a horrible realm of reality. Being able to access every place accessible is a right every woman should enjoy. But, this is in contrast to the harsh reality of today's world, Women have become vulnerable, they're being targeted, molested, harassed and what not. There have been millions of reported cases of 'physical assault' or 'attempt to harm' against women all over the world. The accused usually benefit from the lack of the preparation of the victims and the physical strength they possess. Since physical strength varies from person to person and cannot be matched, the only way to counter these attacks are to surprise the assaulters and create those few moments of terror to stun the assaulters and escape. Thus, a reliable self-defense device is the need of the hour.

2.2. Working and Operation

Principle of Directivity: In general, the directivity of any source depends on the size of the source and wavelengths it is generating. The frequency of sound waves is inversely proportional to the wavelength generated. The ultrasonic devices achieve higher directivity by modulation of audible sound onto high frequency ultrasound. The device uses couple IC 555 timer for the pulse generation. IC 555 timer can be operated in three modes. Astable, mono-stable and bi-stable .In astable mode it works as a free running mode. Output will continuously toggle between low and high, there by generating a train of pulses. Output is emitted out from the front of gun barrel in an cone shape of 45 degrees so that it can be aimed directly at the intended target. This device also has its own on board circuitry for allowance of frequency variations, sweep rate and sweep distance. It is powered by two 9-volts batteries which will last for 20 hours of continuous operation without replacement.

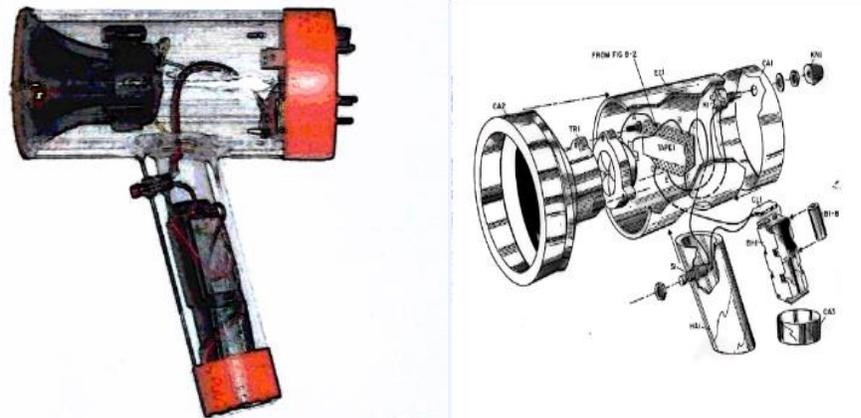


Figure 1:

The unit has control for effecting with its output blasts with the following user adjustments.

- Human beings are able to hear up to about 20 kHz. It allows adjustment of output center frequency from approx 15 kHz to 30 kHz by adjusting knob from back of the unit.
- The sweep is used so that the output will have its frequency automatically swept between two selected frequencies. One complete cycle of frequency variation is called a sweep. After making the Sweep on, it allows the selected frequency to sweep back and forth by approximately 5KHz. Faster and slower sweeps allow the sweep time to be much faster or much slower which can cause intense sonic effects. Output can easily be heard when the trigger is pulled.

These sonic waves can be penetrated through thick walls if properly tuned and usually travel longer distance than audible sound beams. The device doesn't cause any permanent harm, but people feel vast pain and pressure on their eardrums and generally they want to get away from it as quickly as possible. The effect usually disappears after an hour or so.

2.3. Electrical Circuit

Both the IC's are configured as astable multivibrators. The left one is slow rising and falling ramp generator and is applied to pin#5 of high frequency generator. S1 is for Slow/fast sweep option, S3 is frequency selector switch for fixing optimal frequency range. S4 is push to ON used for triggering the circuit into operation. P1 is for correcting the desired sweep speeds .P2 sets the final frequency to be delivered across output. .The circuit operates at 12v of a battery pack made from chargeable Ni-Cd cells.

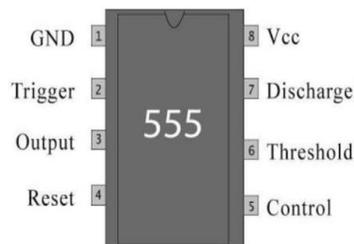


Figure 2: Pin Configuration of IC 555 Timer

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Pin#7 is to discharge the timing capacitors, pin#5 is to supply control voltage and pin#2 is for trigger. . The threshold pin from first IC is fed to the base of 2N2222 transistor through a resistor. A high frequency sweep voltage observed at pin #3 of right hand IC is fed to transistor current amplifier stage. The amplified current is further fed to a couple of inductors which transforms the high current into high voltage frequency suitable for driving high impact piezo transducers or alarm systems. The entire unit must be installed inside a plastic enclosure in such a way that it resembles gun kind of appearance. The piezo must be assembled inside a funnel mouth, and whole assembly to be fixed at the tip of the above fabricated gun barrel.

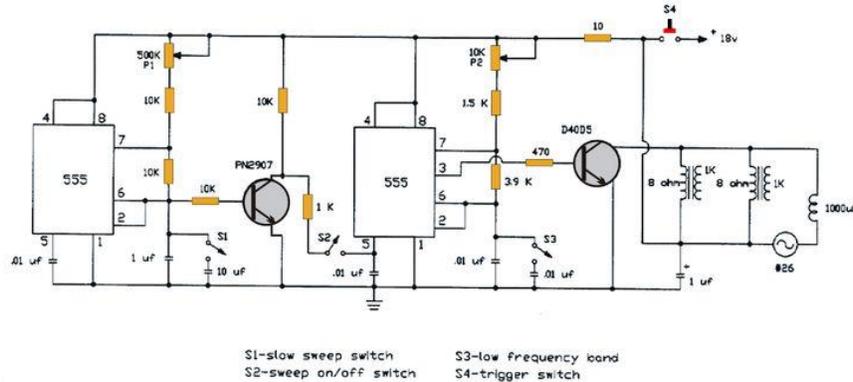


Figure 3:

To increase the unidirectional ability of the ultrasonic wave an extra PAL (Parametric Array Loudspeaker) circuit is used which focuses the sound in the direction in which the device is pointed at.

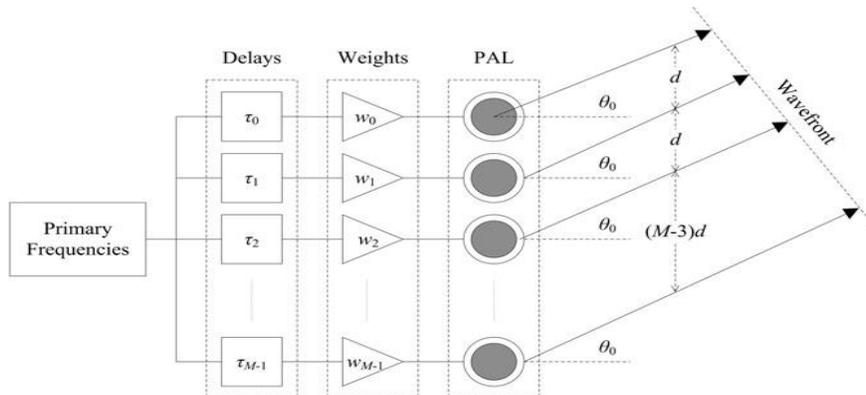


Figure 4: Delay-and-Sub beamforming structure of steerable PAL

The image shows the unidirectional beam emitted from PAL arrangement after the ultrasonic beam from the gun is passed through the PAL.

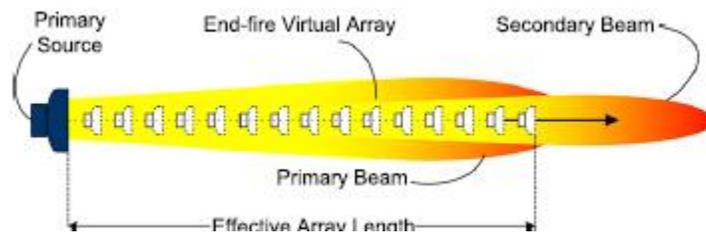


Figure 5:

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The difference frequency generated from interaction of primary frequencies is focused in the same direction as the wavefront formed from primary frequency. Ultrasound limits exposure to 75db SPL (Sound pressure level) for frequencies greater than or equal to 20 khz; and 110db SPL for frequencies greater than or equal to 25khz. Extremely high power and less powerful sound waves can destroy the eardrums of a target and cause severe pain, nausea or discomfort. This is usually sufficient to numb a person. The use of these frequencies has occurred in both counter-terrorist and crowd control settings.

3. Results and Discussions

Alternate non-lethal weaponry is the need of the hour and an ultrasonic device just serves the purpose. In this paper, we discussed about an ultrasonic weapon that can be easily carried and effectively used by women for personal defense. It can also be used to ward off animals away from humans due to ability of some animals to hear in upper frequency bands, so the pain is as much unpleasant as it is to humans. They might cause permanent hearing damage to people if fired too close, but it is acceptable risk than using a gun which can take life. The military is currently working on a high power unit similar to this concept for crowd control and for the use on the battlefield. These kinds of self- defense items for women safety applications won't cross any dangerous limits and will be as effective as other hand guns in the case of emergency.

4. Conclusions & Recommendations

This paper serves as an instructive reference to readers, who are interested in further exploring and expanding this technology, and bringing out its application in other different areas as well. The first portion describes the history and different existing sonic weapons and second portion of it describes how those concepts can be used for implementing women's safety. The time-to prototype might be quite high but it is the future of acoustic weaponry that will serve in its variety of platforms. However, this technique is fully dependent on ultrasound being directional. We can also make use of Acoustic diodes for making it unidirectional. It is the diagnosis for future work to design simple model for women safety.

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