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SOUND BEAM FREQUENTLY ASKED QUESTIONS:

PARAMETRIC SOUND GENERATORS. What is SOUND BEAM?

Hypersonic Sound Beam is a proprietary parametric sound generator, developed and refined over several years of intensive research, and offering a unique approach to generating sound that provides multiple performance advantages unachievable with conventional loudspeaker systems.

What is a parametric sound generator?

A parametric sound generator uses the nonlinear properties of air to create audio sound waves within the air itself by converting an ultrasonic set of frequencies into sound that we can hear. SOUND BEAM is an advanced type of parametric sound generator.

Are there any other commercial parametric sound generators on the market?

SOUND BEAM is the only commercially available parametric sound generator available anywhere in the world at this time. (Underwater communications have also been derived from parametric sound generators, however, they do not operate in air.)

What are the advantages of SOUND BEAM sound reproduction systems over conventional loudspeakers?

SOUND BEAM creates a very directional beam of sound, similar to the light from a flashlight, which can be controlled and directed as desired. This directional focus can be used to:

- Isolate sound to a specific region or person
- Communicate over long distances
- Move sound around a room in real time
- Deliver sound to areas which are either physically impossible to access or too costly to install conventional loudspeakers (create virtual sound sources)

What is a virtual sound source?

It is the creation of the illusion of sound coming from a surface or direction where no physical loudspeaker is present. The area where the listener perceives the sound to be coming from is called a virtual loudspeaker or virtual sound source.

How does SOUND BEAM operate differently from conventional

loudspeakers?

SOUND BEAM technology is quite different from conventional loudspeaker technology. A loudspeaker simply converts an electrical signal containing audio information to audible sound by vibrating the loudspeaker diaphragm. The sound produced by a loudspeaker can generally be heard anywhere in the vicinity of the loudspeaker. SOUND BEAM, on the other hand, emits sound in a highly controlled, narrow beam, so that SOUND BEAM sound can be heard only if you are "in the beam" or in a position to hear the reflected sound from a virtual source created by the beam on a reflective surface.

SOUND BEAM sends out an ultrasonic beam that contains an embedded audio signal. Audio becomes much more directional at higher frequencies and is therefore highly directional at ultrasonic frequencies where SOUND BEAM operates. The ultrasonic beam emitted by SOUND

BEAM does not spread out like the sound from a conventional loudspeaker. The resultant SOUND BEAM audible sound is created by the ultrasonic interaction with the air which causes the audio information to be demodulated from the ultrasonic beam into audible sound.

What are some typical applications for SOUND BEAM technology?

The unique ability to control and direct sound obviously creates new opportunities for designers, architects, and engineers to implement and use sound as never before. SOUND BEAM is applicable in any situation where it is desirable to limit the ability to hear sound to a well-defined space and to eliminate the ability to hear sound where it is not wanted or needed. SOUND BEAM can also be used to create virtual loudspeakers, so that the sound appears to be coming from an area where it would be impractical or impossible to place a loudspeaker.

What aspects of SOUND BEAM Technology have been or are being patented?

- Distortion Cancellation Signal Processing
- Ultrasonic Emitter (Transducer) Devices and Configurations
- Ultrasonic Power Conversion / Amplification
- Pre-Recorded and Real Time SOUND BEAM Systems
- Multiple Commercial, Industrial, Military, and Consumer Product Applications

What are the advantages of the proprietary SOUND BEAM technology over other attempts at building parametric sound generators?

Other attempts at parametric sound generators historically have been plagued by either very high distortion or distortion correction approaches that required very wide bandwidth systems causing:

- (1) The need for emitters which are impractical and too costly to build and
- (2) Generation of secondary distortion components in the audible range. Sound Beam technology has developed a sophisticated distortion correction system that virtually eliminates distortion while requiring a zero increase in system bandwidth. It actually requires only one-half the bandwidth of the non-distortion-corrected signal allowing effective use of real world, cost effective, transducers (emitters) and eliminating audible artifacts.

Emitter Ultrasonic Plane Waves

Other attempts at parametric devices have also utilized arrays of individual, small, ultrasonic transducers originally intended for use as single devices and not for parametric applications. When used in multiples, these devices tend to have mismatched phase and amplitude responses and reliability problems (among other things) that limit their effectiveness for use in parametric sound generators. Also, arrays of the size needed for parametric systems using individual devices are extremely cost prohibitive.

Monolithic, thin film, ultrasonic emitters have been developed, that utilize a single, unified film structure which is highly phase and amplitude coherent across the entire device and are the only 'purpose built' emitters for parametric use. They have the added advantage of significantly lower cost than previous 'non-purpose-built' devices. Hypersonic Sound Beam has also designed the first ultrasonic power amplification system specifically optimized for parametric power conversion. The ModAmp™ (Modulation Amplifier) Technology uses sophisticated digital switching techniques to achieve both very low distortion and very high efficiencies. Further, the ModAmp can inherently incorporate both the parametric modulation

process and the power conversion process in one stage of electronics, replacing costly and bulky, multi-stage (individual components), and inefficient systems of the past. The very high levels of efficiency in this design allow for the elimination of the additional heat sinks normally required while providing virtually any required power level in a package that can be as small as a deck of playing cards.

Remaining Hypersonic Sound Beam intellectual property includes methods for prerecording modulated and distortion corrected audio onto digital storage mediums such as CDs, flash memory, etc. This allows the convenience of a simplified parametric system, totally eliminating the cost and bulk of on-board processing electronics. It can also provide for updating of the signal processed audio files through the internet or other convenient transmission mediums.

What is the diameter and the directivity of the ultrasonic beam and what affects it?

The ultrasonic beam is comparable in diameter to the active surface area of the SOUND BEAM emitter array. Due to the wavelengths of the ultrasonic frequencies being on the order of less than 1/20th the diameter of the smallest emitter, the ultrasonic wave will be emitted as a pure plane wave with virtually no expansion in the column diameter with distance. The ability to maintain this high level of directivity is sustained by having a large emitter diameter compared to the wavelength of the primary ultrasonic frequency.

How long is the ultrasonic column and what determines its length?

The length of the ultrasonic beam is dependent upon several factors. Tightly focused beams travel farther than widely dispersive (non-focused) beams before completely dissipating in air. The length of the column is determined by the overall size of the emitter device, the primary ultrasonic frequency, and the absorption rate of the primary frequency by the air. The ultrasonic beam sound pressure level is highest at the surface of the emitter and it rapidly drops to zero over distance as it is absorbed by the air.

At the SOUND BEAM operating frequency, the length of the ultrasonic beam is on the order of 20' (6.1m) for a typical SOUND BEAM application.

What is the relationship of the ultrasonic beam to the audible sound beam?

At the surface of the emitter, the beam is 100% ultrasonic. As you observe the output at greater distances from the emitter, the air begins to demodulate the audio, and this process continues throughout the usable length of the ultrasonic beam. This is what causes SOUND BEAM to actually sound louder at greater distances from the emitter. At some distance, usually greater than 20 feet, the ultrasonic beam will dissipate to a lower level than the audio, no longer contributing significantly to the production of audible sound. The directivity of the column of audible sound and the lowest frequency to which the system maintains directivity is determined by the effective length of the ultrasonic column. To even approach the directivity control of SOUND BEAM, a conventional loudspeaker would have to have a cone at least 10' (3m) in diameter, as apposed to an SOUND BEAM emitter array which can be less than 1' (30cm) in diameter.

At frequencies above 100 Hz, the directivity of the audible sound is generally comparable to the directivity of the ultrasonic column, since the audio is produced in plane waves, just like the ultrasonic column. In general, this is less than 6 ϕ^a dispersion overall (3 ϕ^a off each side of the emitter).

How far does the audible sound travel?

The audio sound profile of SOUND BEAM is completely different than a conventional loudspeaker, which produces the loudest sound at the speaker, but falls off rapidly (following the 'inverse square law') as the distance from the loudspeaker increases. SOUND BEAM, in contrast, sounds louder as the distance between the transducer and listener increases, up to a point, then diminishes at a rate substantially less than conventional loudspeakers as the distance continues to increase. SOUND BEAM maintains intelligibility to much greater distances than a conventional speaker. The reason that the loudness of conventional loudspeakers falls off with distance is because the audio is being produced in a substantially spherical pattern (radiating in all directions). With SOUND BEAM, the audio is contained within a tightly controlled beam.

Are there any safety concerns using SOUND BEAM?

No. Airborne ultrasound is not harmful to people or animals at the power levels used in SOUND BEAM. The maximum power levels used in SOUND BEAM fall well within the accepted worldwide safety standards for airborne ultrasound established by the *International Conference of Industrial Hygienists*. In addition, the proprietary modulated primary frequency system used by SOUND BEAM varies the sound pressure level of the ultrasonic beam proportionally with the audio signal. In other words, in the very quiet sections of the audio program, the ultrasonic carrier is reduced accordingly in real time, and when no audio program is present, the ultrasonic beam is gone altogether. This further reduces the average ultrasonic output to levels even further below the accepted standards.

This system also saves power by allowing the amplifier to generally operate at 50 - 80% reduced levels, based on the audio program material. Also, the narrow bandwidth requirements of our proprietary SOUND BEAM modulator restricts the extension of any primary frequencies from approaching the audible range. Early tests indicate that SOUND BEAM can be a very effective communication device at distances of hundreds of feet with very little attenuation to the audible sound.

What affects how far the audio will project over distance?

How far the audio will project over distance is effected primarily by the frequency of the ultrasonic column and secondarily by the diameter of the emitter array, which ultimately determines the length of the ultrasonic virtual sound generator. HSB's sound generators operate on a similar basis to what is known as an 'end fired array'. An 'end fired array' is realized by using 100 or more conventional transducers lined up directly in front of each other in the shape of a long column. This is one way highly directional sound could be produced using conventional loudspeakers, however, this has never been a practical approach due to size, cost, and complexity.

SOUND BEAM operates as if it has an infinite number of transducers all along its ultrasonic column, each contributing to the output level and directivity of the audible sound. This highly directional, projected sound can now be achieved through SOUND BEAM with an emitter only inches in diameter and 0.4" (10mm) thick.

SOUND BEAM COMMERCIALIZATION

How loud is SOUND BEAM?

At the current stage of development, SOUND BEAM can produce >95 dB of audible sound at 20' (6.1m) with a 10.88" x 10.88" x 0.4" thick (27.6cm x 27.6cm x 10mm) emitter array and can also maintain a similar level over much greater distances.

How durable is the SOUND BEAM Emitter device?

In terms of durability, SOUND BEAM is at least equal to, and in some ways superior to, conventional loudspeakers. The transducer is quite durable, however, it is usually mounted in a protective enclosure to protect it in the same manner as other equipment would be protected.

How does SOUND BEAM mount to a wall or other location?

The first Sound Beam model has a standard mounting bracket available; however, most users will likely provide their own mounting approach designed specifically for their unique application.

Are there any mounting restrictions?

No. SOUND BEAM can be mounted just about anywhere. SOUND BEAM should be mounted securely so that it can't be moved. One should be sure that it remains "aimed" in the correct direction. Because SOUND BEAM has no rear sound wave, it can be mounted directly on a wall or other hard surface and can also be embedded inside other equipment. It is even possible to conceal the Sound Beam behind a light Scrim material so as to completely remove it from view.

Can the emitter be mounted in a separate location from the electronics?

Yes, however, several considerations are necessary for UL and FCC compliance. One is that a shielded cable be used between the amplifier and emitter and the other is that the emitter be mounted in an acceptable enclosure. IRI can provide appropriate cable and connection specifications to fulfill each specific application requirement in the proper volume.

Are there any environmental limits?

The emitter requires protection from direct rain and snow. High humidity does not pose a problem. If water collects on the emitter surface, the output level may be slightly affected. However, as soon as the surface dries, performance will return to normal. High humidity can actually increase the efficiency of the parametric conversion process in air, causing greater sound pressure levels at greater distances. Specialized emitters and hardware can be appropriately adapted for extreme applications. The SOUND BEAM process itself is not generally affected by inclement weather.

Does the amplifier design have any effect on the performance of SOUND BEAM?

Yes. The amplifier must operate with low distortion at 40 kHz and the power output must be adequate to produce the required ultrasonic sound pressure level. Due to the requirements for a combination of several processed and phased audio signals and a control signal modulated onto an ultrasonic carrier frequency, this processing can be integrated directly into the SOUND BEAM ModAmp. The ModAmp has significant advantages over any other alternative amplification system.

What is the usable frequency bandwidth of the audio?

Audio bandwidth is dependent primarily on the maximum audio SPL required and secondarily on the size of the emitter array. The first system designed for 'Point of Purchase' applications maintains a useful frequency range of 350 Hz – 16 kHz.

What is the warranty period?

SOUND BEAM systems are provided with a one year limited warranty.

How do I get SOUND BEAM service if required?

All SOUND BEAM warranty service is performed by simply exchanging the unit. During the warranty period, a replacement unit will be shipped at no charge as long as the defective unit is returned to the factory within 30 days. After the warranty period has expired, customers have the option of either sending their unit to the factory for repair or purchasing a new unit and receiving an exchange allowance for their defective unit.

TECHNICAL ENGINEERING QUESTIONS

How is the audio output level of SOUND BEAM related to the ultrasonic SPL?

Increasing the ultrasonic SPL by 3 dB (by turning up the amplifier gain by 3 dB, for example) will result in a 6 dB increase in the audio output level of the SOUND BEAM system, up to the point of air saturation.

What is the ratio of ultrasonic SPL to audio SPL within the effective ultrasonic beam?

In general terms, 110 dB of ultrasonic SPL on average will produce 80 dB of audible sound. The actual conversion efficiency in air is dependent on frequency, distance, and the setting of the modulation & processing parameters.

Is there a lower limit to the audio dynamic range which SOUND BEAM can produce?

There is no lower limit. The system will continue to produce audio all the way down into the noise floor.

How much voltage is applied to the emitter array?

As with conventional loudspeakers, the SOUND BEAM drive voltage is dependent on program level and volume setting. However, the maximum voltage ever applied directly to the emitter is approximately 200 VAC RMS. Small, ultrasonic step-up transformers can be attached directly to the emitter devices allowing for very low voltages to be carried by the connecting cables.

How much AC power is needed?

The typical SOUND BEAM dual emitter, pre-recorded playback system draws a maximum of 1 amp at 120 volts (120 watts). The average required power is approximately 60 watts depending on the audio program material. Systems with larger emitter arrays and amplifier systems will require higher power.

Does SOUND BEAM require any special cabling between the amplifier and the emitter?

Current systems use coaxial cable to eliminate any possibility of signal interference. While twisted pair with adequate insulation will also work, in order to comply with FCC Part 15 regulations we do not recommend it. The production design will or can have the transducer and electronics in the same enclosure, which will eliminate the need for any lengthy interconnect cabling.

Does feedback occur using a live microphone with an SOUND BEAM system?

The directivity of an SOUND BEAM system allows you to direct the produced audio away from any live microphone, significantly reducing the tendency to feedback. Early testing also suggests that the actual conversion process from ultrasonic frequencies to audible frequencies lessens the tendency of an SOUND BEAM system to feedback even when directed toward a live microphone.

Will there be more than one emitter type?

Yes. A number of emitter types are being developed and expected to be available, each with a matching set of electronics. Choice of appropriate emitter device will be based on the specific application requirements.

Does the distortion of the audio change with distance?

While distortion does change slightly with distance, using Sound Beam's proprietary distortion cancellation system, the distortion at any distance will be maintained at low levels at all effective distances from the emitter array.

What government agency approvals are required for SOUND BEAM?

This proprietary SOUND BEAM technology meets all appropriate FCC regulatory requirements and carry the UL label indicating that all UL safety requirements have been met. The United States FDA has issued a 'clearance to market' for SOUND BEAM technology as covered under Title 21, CFR, subchapter J as it pertains to ultrasonic devices for other than medical device applications. The abbreviated report is pursuant to Section 1002.12 of the regulations. According to this report, the FDA has assigned the following Accession numbers to SOUND BEAM™ products: 0181485 and 0191486.

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