INFORMATION

HSS®

TECHNOLOGY INTRODUCTION

How HSS™ can shape the future of sound.

American Technology™ CORPORATION

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HyperSonic™ Sound is a completely new technology that creates sound "in air."

It is a new paradigm in sound production based on solid, well-known principles of physics.

There are no enclosures, crossovers, woofers, midrange or tweeter elements. The sound is generated in the air itself, indirectly, as a conversion by-product of the interaction of ultrasonic waves.

HyperSonic™ Sound is NOT a new upgraded surround-sound system using old technology.

Nor is it a mixing or amplification system designed to trick the listener's ear. It is not a new driver for polyfoam or styrofoam diaphragms, a new speaker enclosure or some sort of digital speaker system (which still drives diaphragms mechanically).

These days it is highly unusual to find something that is truly original. The terms "quantum leap" and "paradigm shift" are so overused that, when one runs across a technology that is truly worthy of such a description, few believe it.

Fortunately, like all extraordinary developments, HyperSonic Sound can be described with an economy of words:

About a half-dozen commonly used speaker types are in general use today. Whether they be dynamic, electro-static, ribbon, or some other transducer-based design, all loudspeakers today have one thing in common: they are direct radiating—they are fundamentally a piston-like device designed to directly pump air molecules into motion to create the audible sound waves we hear. HSS technology produces sound in the air indirectly as a by-product of another process.

HyperSonic Sound Technology projects a beam of silent ultrasound energy into the air. The air itself creates audible sound within the column of ultrasonic energy. The sound is actually created in mid-air. This is not an illusion. The acoustical sound wave is created directly in the air molecules by down-converting the ultrasonic energy to the frequency spectrum we can hear. An important by-product of HSS is that sound may be directed to just about any desired point in the listening environment. This provides outstanding flexibility, while allowing an unprecedented manipulation of the sound's source point.

See page 11 for a more detailed description.

Potential HyperSonic Sound Applications

HSS™ puts sound only where it is needed.

Do you need to communicate clearly and efficiently over long distances to a single group of people? HSS lets you "beam" sound to a single point hundreds of feet away.

Focus drive-thru restaurant ordering station sound directly into the car window, eliminating "noise pollution" of the surrounding environment.

In a grocery store aisle, advertise a special sale price or promotion directly in front of the product... without disturbing other customers.

HyperSonic Sound can "focus" audio at your tradeshow exhibit. It lets you communicate directly with your target customer at a demonstration kiosk without bothering anyone else around the exhibit.

As you move from display to display in a museum, Hyper Sonic Sound can present the "audio story" for each individual display.

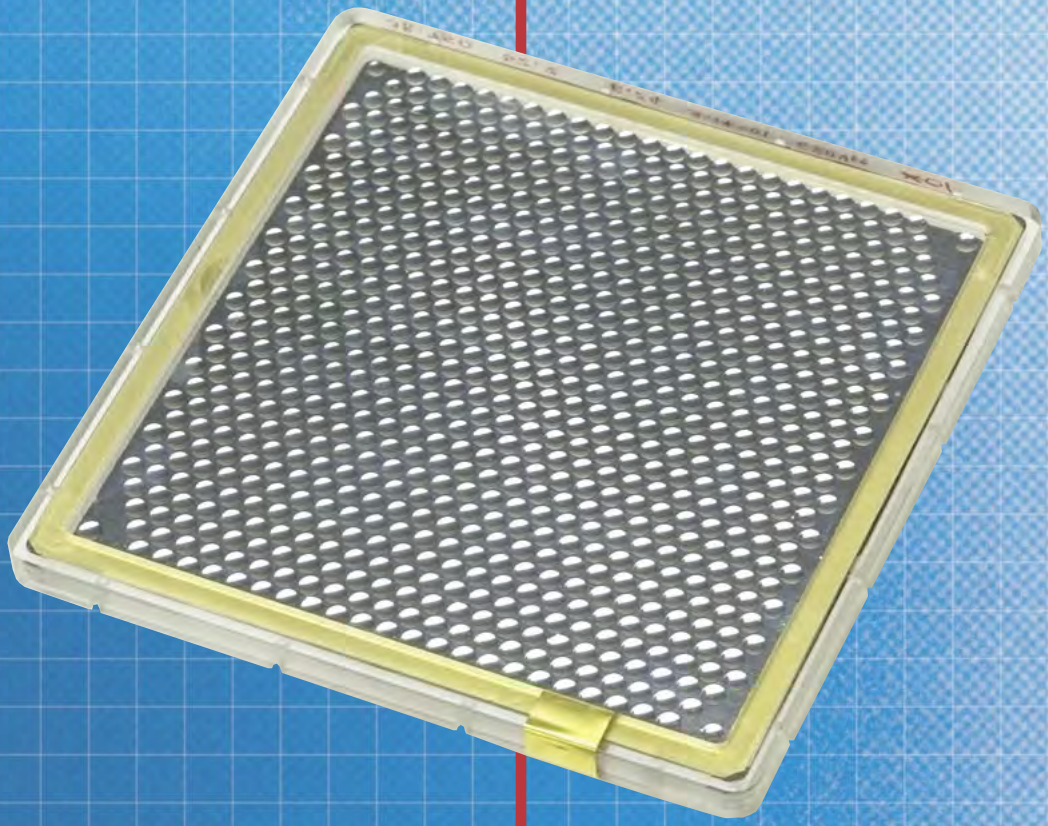
Bottom line: HyperSonic Sound is the first audio technology that allows individual communication in public spaces.

Potential applications & markets include…

- Paging Systems
- Communications
- Toys / Novelties
- Cinema / Theater
- Sound Reinforcement
- Museums
- Retail Stores
- Amusements
- Theme Parks
- Kiosk Displays
- Trade Shows / Events
- Audio Conferencing
- Noise Cancellation
- Military Communications
- Aircraft Communications
- Automobiles

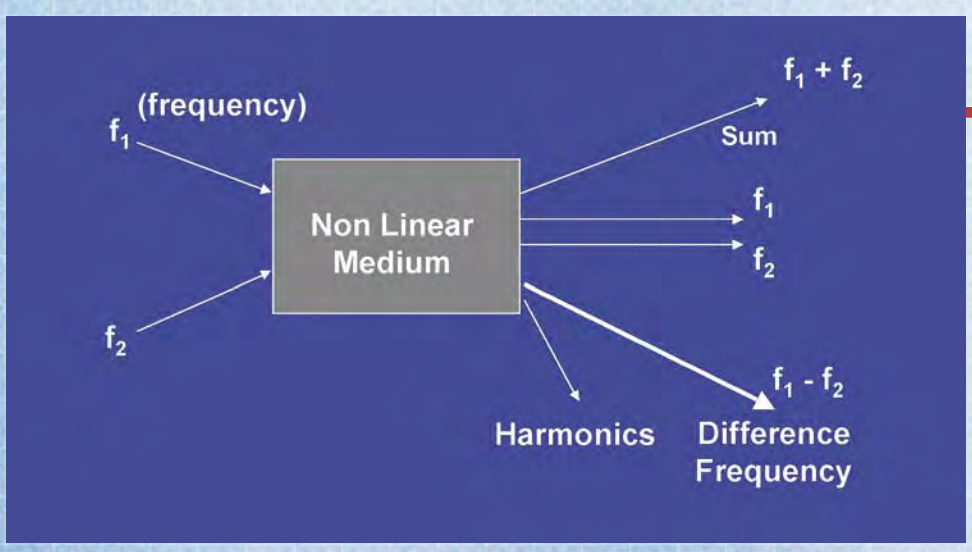
Just think of the THOUSANDS of possi-bilities for specific products which might fall into one of the market categories listed at left. Given the unique properties of HyperSonic Sound, we have the potential for many new products that haven't even been thought of yet!

Proprietary PVDF Film Emitter



As you can see, the first proprietary HSS™ ultrasonic emitter device is flat, thin and easy to mount.

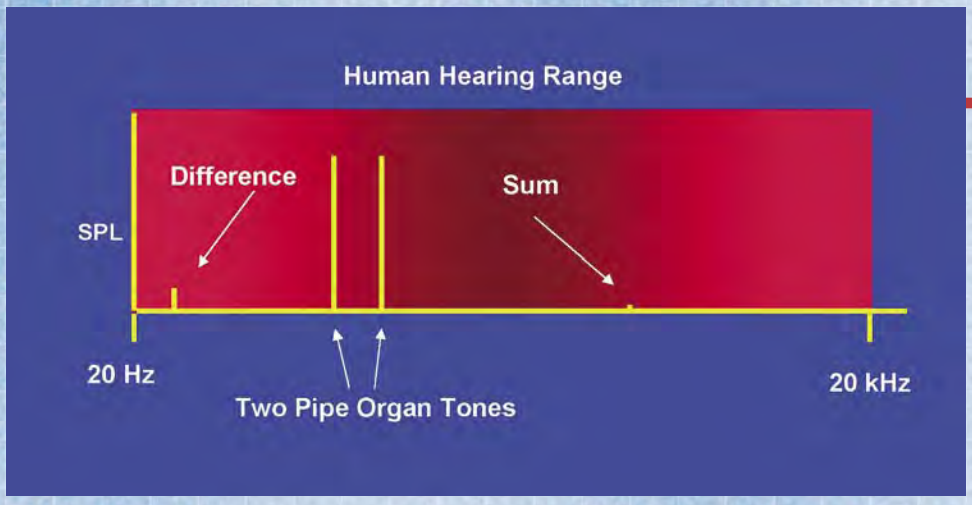
Basic HSS™ Technology Overview



NOTE: For a detailed scientific study of HSS™ covering all aspects of the mathematical and physics aspects of HSS™, please refer to the ATC white paper titled "Theory, History, and the Advancement of Parametric Loundspeakers - A Technology Overview"

A Non-Linear Medium

It is understood from the world of electronics, that sending two frequencies (represented here by f1 and f2), into a Non Linear device (such as a mixer or heterodyne circuit) produces an output which contains both of the original signals F1 and F2, plus the sum of the two, the difference of the two, and a set of harmonics. For HSS, we are most interested in the difference frequency, f1 minus f2.



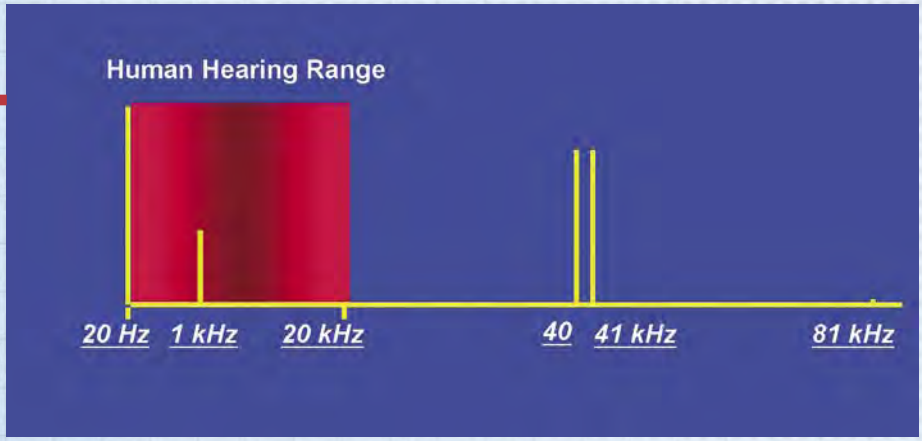
The Helmholtz experiments were further explained 150 years later by Westervelt (Brown University) and Blackstock (University of Texas at Austin). They proved that the new tones were the result of propagation distortion caused by the air itself.

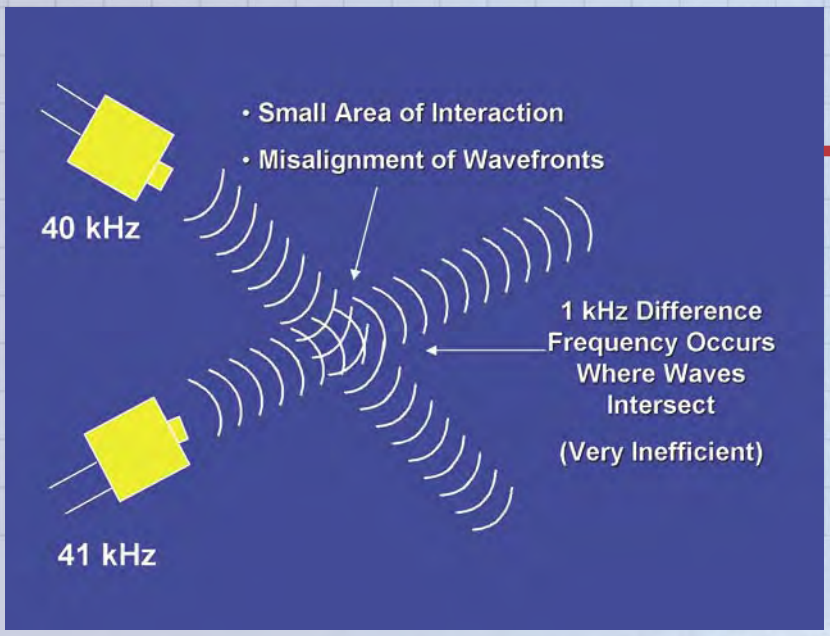
Air is a Non-Linear Medium

Approximately 150 years ago, a German Physicist named Hermann von Helmholtz discovered that air is non-linear. He played two organ notes very loudly on his pipe organ and was able to hear what he thought to be a higher frequency and a lower frequency. Through careful measurement, he proved that these new frequencies did exist as new tones and were measured to be the sum and the difference of the original notes.

Moving Fundamental Tones Beyond Range of Hearing

"What if we move the two fundamental tones beyond the range of hearing?" If, for example, we could project 40 kHz and 41 kHz tones into the air, the physics tell us that we would produce a "sum tone" of 81 kHz, (well beyond the range of hearing) and a "difference tone" of 1 kHz which we can hear.
Since we do not often listen to sine waves, ATC decided to find a method to produce complex wave sounds in the air such as voice or music.



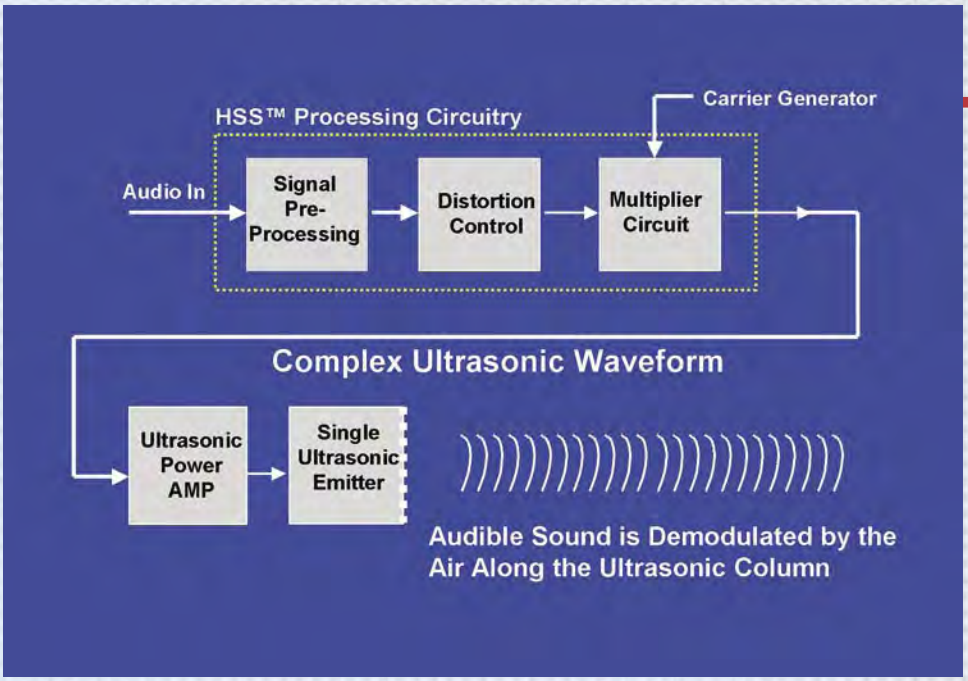


One Type of Earlier Approach

Previous to ATC, work was done by others using two ultrasonic emitter devices. One emitter produced 40 kHz and the second emitter produced 41 kHz.
A 1 kHz tone was produced in the area where the two ultrasonic wavefronts cross.

However, the small area of interaction and the phase misalignment of the wavefronts caused very little sound to be produced. This effect was measurable, but very inefficient and not practical as a commercial device.

ATC, however, was able to improve on this method. We developed a set of electronics which could produce a complex waveform containing all the required components to make difference tones in the air, and then projected that waveform from a single, ultrasonic emitter!

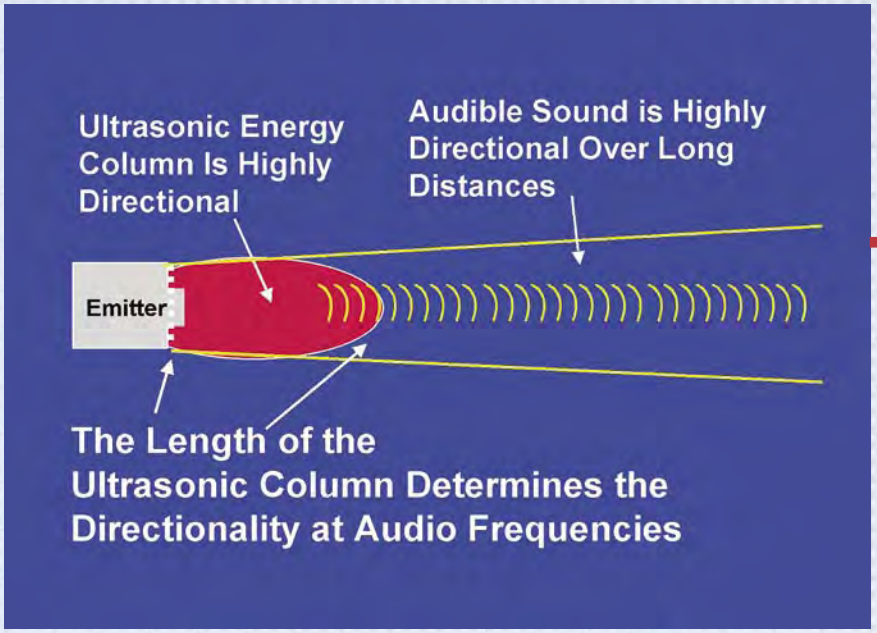


Basic HSS Block Diagram

And that is the basis of HyperSonic Sound technology. Audio is sent to a proprietary* electronic preprocessor circuit, distortion control circuit, and then through a multiplier circuit where a composite ultrasonic waveform is produced.

This ultrasonic signal is then amplified and sent directly to a proprietary emitter device. A column of ultrasonic energy is produced in front of the emitter which contains all required properties for the air to produce audio frequencies or sound that we can hear.

Audible sound is demodulated all along this column of ultrasonic energy.



Ultrasonics & Audio

As the ultrasonic sound wave dissipates, the sound pressure level of this wave will fall below the air's threshold of non-linearity and will no longer produce difference tones (audible sound). Audible sound is demodulated by the air all along the column of ultrasonic energy and continues to propagate far beyond the region of the ultrasonic energy.

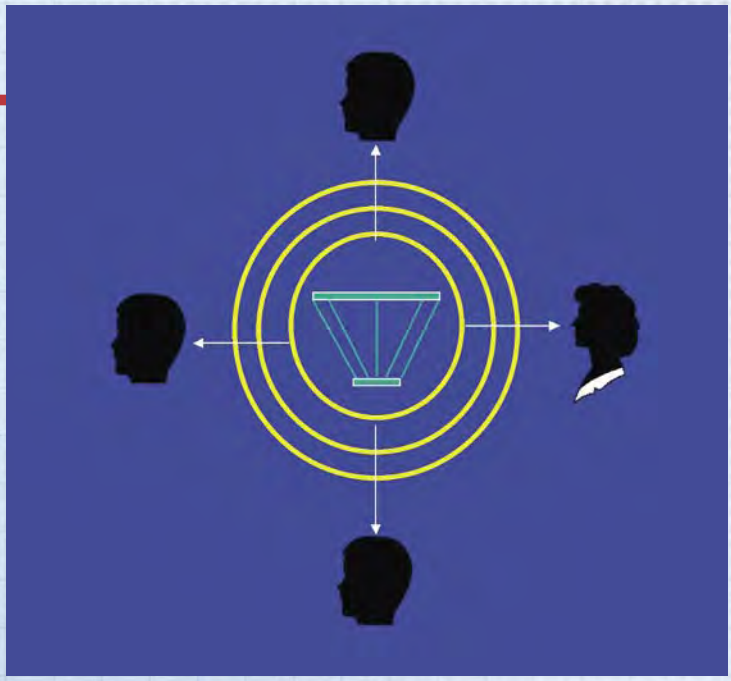
The length of this useful ultrasonic column can be referred to as the "Effective Beam Length" and can be controlled by adjusting the carrier frequency and array configuration. A longer effective beam length will provide greater directionality.

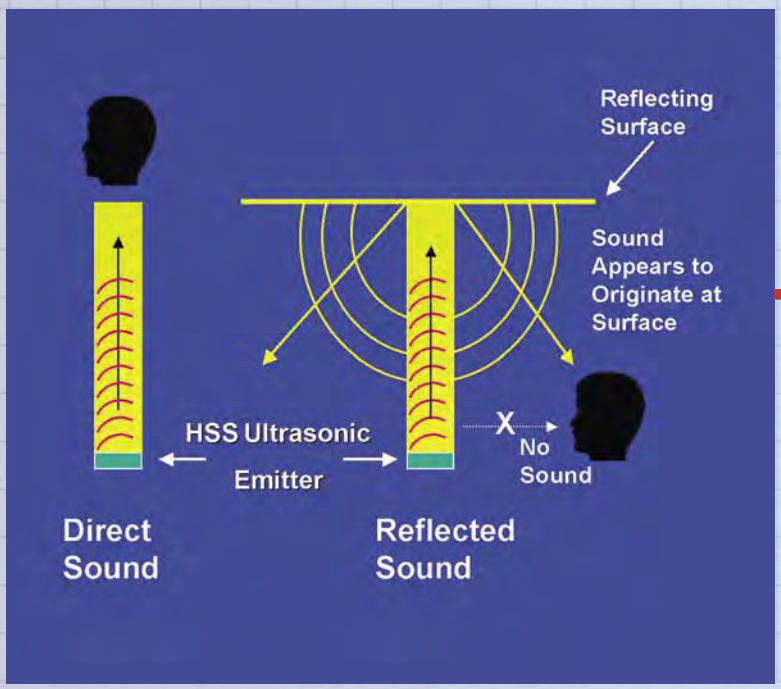
This brings us to the first major benefit of HyperSonic Sound™ - controlled directionality. The audio is highly directional because it is created in a virtual end-fired array (the ultrasonic energy column). This end-fired array is relatively long because the ultrasound is highly directional.

Conventional Loudspeakers

Think of a conventional loudspeaker for a moment. It basically radiates sound in all directions. It does not matter where the listener is positioned, he will always hear the sound from the loudspeaker. You can point directly at the loudspeaker from anywhere in a room and say "that is where the sound is coming from."

We might think of the loudspeaker as a light bulb. A light bulb spreads light in all directions, just as a loudspeaker spreads sound in all directions.





Direct Sound versus Virtual Source Sound

HSS™, however, is more similar to a flashlight. If you project the HSS emitter device directly towards a listener, he would hear the sound formed in the column of ultrasonic energy just like he would see the light from a flashlight, if it was aimed directly at him.

However, If a listener stands to the side of an HSS emitter, he only hears the sound that is reflected from a boundary surface, just like he would see the light of a flashlight only when it is reflected off the wall. Since the listener does not hear any sound from the emitter itself, he hears only the sound that is reflected from the wall.

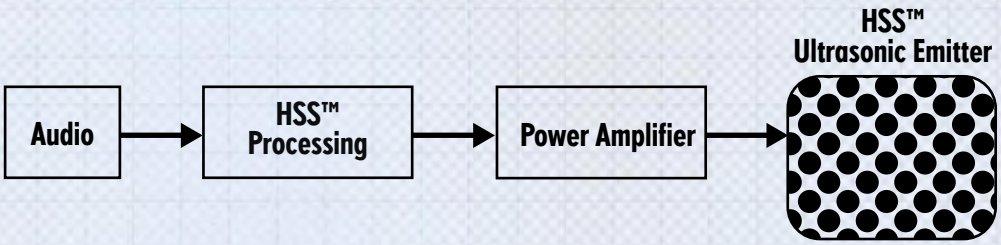
Never, in the history of loudspeakers have we been able to apply this degree of controlled directionality to audible sound.

HSS™ Technology Roadmap

Two Basic HyperSonic Sound Types

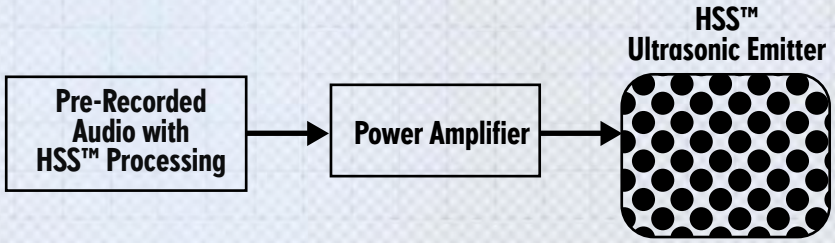
Real Time HSS™

Real Time HSS contains a full HSS system including electronics pre-processing, modulation circuitry (Analog or Digital), amplifier, emitter interface, and final HSS emitter. To be used when the audio signal is changing in real time. For example: Drive Through Restaurant Ordering, Bull-Horn Communications, Airport Public Address, etc.



Playback HSS™

Playback HSS allows an end user to pre-process the audio source for playback and record this material in an appropriate playback device. The processed signal can then be sent to a single or multiple amplifier/emitter channels for output. To be used when the same audio signal is played over and over. For example: Museum Exhibits Playback, In Store Advertising, Theme Park Effects, etc



BENEFIT: Dramatically Reduced Implementation Cost

Two HSS™ Electronic Implementations

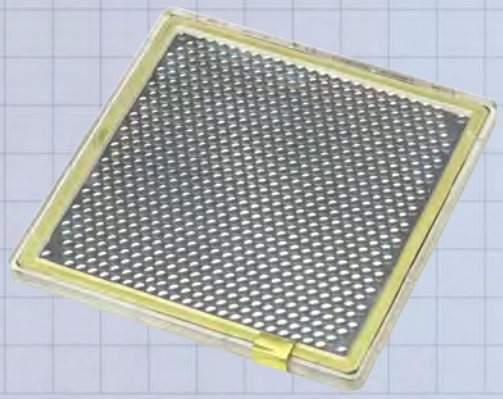
Digital Signal Processing (DSP)

- Reduced Distortion
- Higher Sound Pressure Levels
- Ability to Customize Individual Parameters based on Application Requirements
- Cost Variability based on Specific Application Requirements
- Examples: Most all HSS applications.

Analog Processing

- Less Distortion Control
- Examples: Toys, Novelties, Signaling, etc.

Current PVDF Film Emitter



While the low frequency, directivity, and max SPL performance of HSS™ is proportional to the overall emitter size (surface area), the size and shape can be varied for special applications. ATC will make available different size and types of HSS™ emitters as Licensees and applications warrant.

Current and Future HSS™ Versions

Version 1.0
(Delivered 2001)

- Hybrid DSP modulator circuit board
- Analog modulator circuit board available as an alternative
- Discreet Class D amplification
- Proprietary PVDF Piezo film emitter device

Version 2.0
(projected)

NOTE: future versions are subject to change based on customer and market demand.

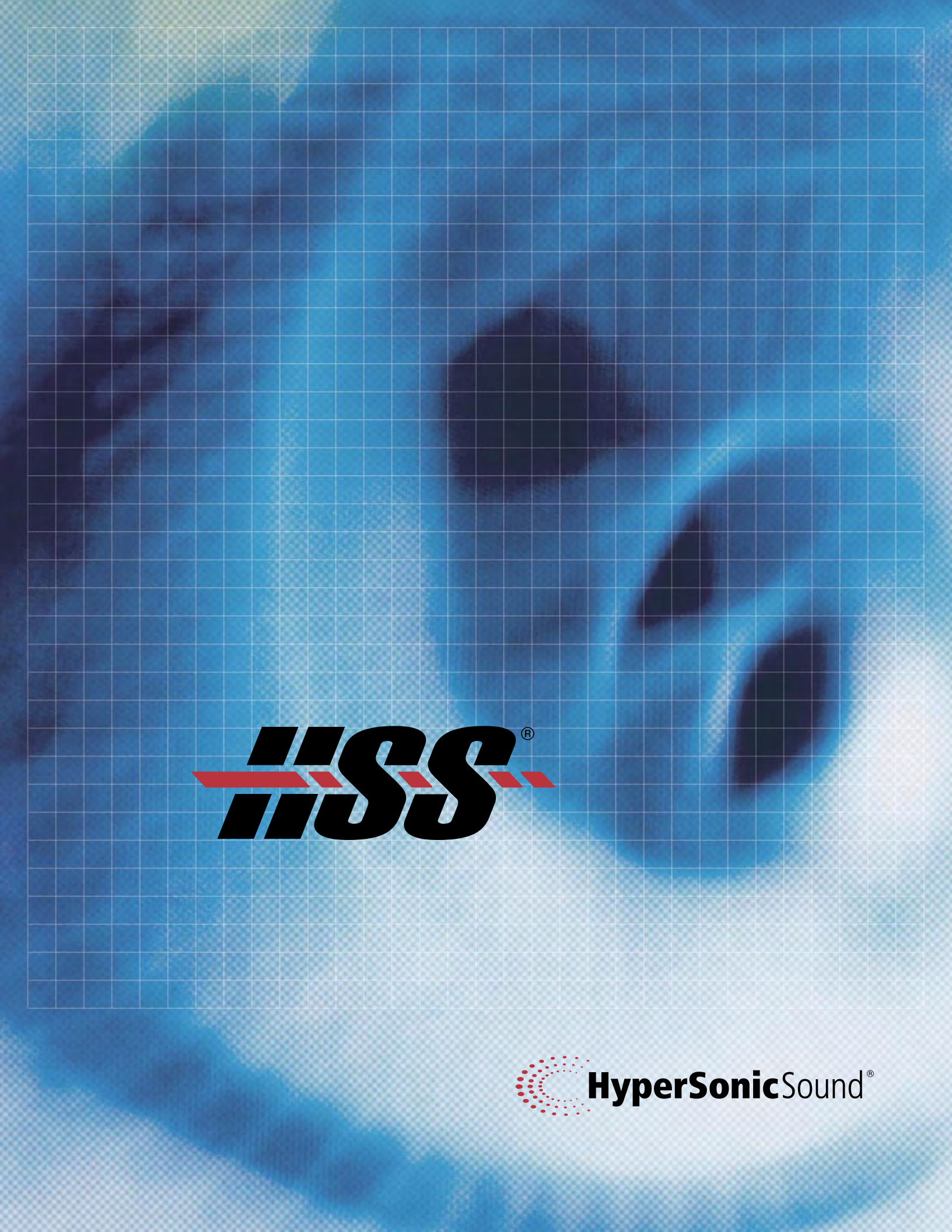
- Improved performance
- Dynamic carrier modulation
- Physical size reductions
- Extended bandwidth
- Size reduction of digital and analog circuitry
- Alternative amplifier designs
- Cost reduction
- Alternative emitter sizes (based on specific applications requirements)
- Portable capability

Version 3.0
(projected)

- Continued performance and bandwidth improvements
- Reduction of DSP and analog solutions to ASIC chip set
- Potential new emitter type
- Cost reduction
- Miniaturization

Version 4.0
(projected)

- Performance improvements
- Miniaturization
- Cost reduction
- Beam steering (real time directivity control)


HSS®
HyperSonicSound®

HyperSonic Sound Technology Benefits

Ultrasonic Emitter Devices

Not only has the conventional speaker's crossover network and enclosure been eliminated, but HSS' ultra-small radiating ultrasonic emitter is so small and light-weight that the inertial considerations ordinarily associated with traditional direct-radiation speakers are virtually non-existent. (And so is just about everything else associated with the conventional speaker: the voice coil and support structure normally used to attach the moving cone in place.)

- Small & light weight
- Easy to mount, very thin & flat
- No Mechanical Vibration or Microphone coupling
- No magnets or voice coils
- No cabinets, boxes or housings required
- No back wave emissions, can be surface mounted

Controlled Directionality (Directivity)

Using HSS Technology, designers could control the vertical and horizontal size of the ultrasonic energy column. Sound could be "focused" directly at the listening audience, reducing the reflections and destructive interference from the surrounding walls, floor, and ceiling. For the first time in history, we can largely ignore the negative effects of room acoustics on sound reproduction.

Project audio over long distances while maintaining intelligibility

Since the projection of HSS over long distances does not follow the traditional Inverse Square Law, HSS is ideal for long distance audible communications. HSS will maintain intelligibility for hundreds of feet, far more than any conventional speaker system. Since SPL is significantly maintained for long distances, the SPL at the emitter can begin at a lower level than conventional speakers. We no longer need to deafen those close to the speaker in order to communicate long distances.

Reduce microphone / speaker feedback

One byproduct of the non-linear de modulation process is a break in the traditional microphone / speaker feedback loop. Live microphones can be used with HSS with improved feedback immunity.

Technology paradigm shift

This is change to build and market something "truly new". Your customers require the benefits of HSS and they will be excited by the marketing potential of a technology paradigm shift.

HyperSonic Sound Documents Available from ATC

HSS™ Data Sheet
Available from ATC or download from www.atcsd.com

HSS™ Technology Introduction (This Document)

HSS™ Technology White Paper (Available under N.D.A.)
Includes a complete review of HSS history and detailed technical disclosure including the math, physics, and sciences of HSS.

HSS™ Technology White Paper (Abridged Version)
Available from ATC or download from www.atcsd.com

HSS™ Applications Evaluation Kit Operating Instructions
(Available with HSS Applications Evaluation Kit). Includes specific engineering information about the kit

HSS™ Licensing Guidelines (Overview of Licensing Policies, Procedures, Terms, and Conditions)
Available from ATC

Review and Analysis of Available Data on the Effects of Airborne Ultrasound on Humans (White Paper)
Available from ATC

American Technology™ CORPORATION
Shaping the future of sound™

13114 Evening Creek Dr. S.
San Diego, CA 92128
Tel: 858.679.2114
Fax: 858.679.0545
www.atcsd.com

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