Acoustic Research

Advanced Development Division

AR-10π loudspeaker system

AR and high fidelity

From its inception Acoustic Research has had a strong interest in basic research. Its primary goal was to apply the body of scientific knowledge in audio, acoustics, and related fields to the design of loudspeakers for home use. In doing so, AR was able to incorporate significant discoveries and developments of its own, where appropriate, into commercial products.

That AR achieved a substantial measure of success is a matter of record. The acoustic suspension system and the hemispherical dome high-frequency unit were introduced by AR, as was the first commercially successful turntable to incorporate independent suspension of platter and arm. Now, some twenty years later, the great majority of the speaker systems on sale throughout the world are based on the same acoustic suspension principle, and many make use of dome radiator tweeters as well. Very few modern turntable designs have not borrowed features from the AR turntable.

AR's long-standing objective has been the accurate reproduction of sound in the home. Accurate sound reproduction was first made a reality under the closely controlled conditions of the laboratory. The lessons and techniques learned were subsequently incorporated into products that significantly improved the realism with which music could be reproduced in the home.

To illustrate the degree of accuracy of sound reproduction that AR speakers made possible, AR staged a number of 'live versus recorded' concerts, in which the sound from AR speakers was compared directly with the sound of 'live' musicians. Invariably most of the audience was unable to tell live from recorded. Simulated live versus recorded tests have always played an important part in AR's laboratory development and quality control programs.

Such tests contribute significantly to the effort to achieve accuracy of sound reproduction in the home. However, for the ultimate degree of success, conditions must still be quite finely controlled, by means of elaborate equipment and sophisticated test procedures, largely in order to account for room effects. It is apparent therefore that significant new steps toward the ultimate goal of musical accuracy in the home must necessarily be based on treating the loudspeaker/room combination as part of the playback 'system'.

The AR-10π is a new speaker system from Acoustic Research that addresses itself to these considerations. Under actual listening conditions, the AR-10π delivers as flat an energy response as the state of the art permits. And it is able to maintain this response characteristic under a great variety of conditions of use. The result is a further significant improvement in the degree of realism with which music can be heard in the home.

The AR-10π offers flat energy response in most listening environments

Uniform energy response
The basic technique of high fidelity is to produce a sound field at the ear of the listener in his home that accurately represents the information on a recording. If it is assumed that the electrical signal coming from the recording is an accurate representation of a musical sound, or of a record producer's intention, it is clear that the job of the speaker is to transmit an accoustic version of this signal unaltered to the ears of the listener.

For proper results the speaker must deliver the same signal for any likely listening position in a listening room. Only if this condition is met will listeners in different parts of the room hear the same performance in the same way. A speaker that meets this requirement is one that delivers flat energy response together with uniform dispersion at all frequencies.

The net result of such speaker performance is a high degree of musical accuracy. If the sound of a Stradivarius violin played in a particular acoustical environment has been accurately registered on a record or tape, it can be accurately reproduced only by a speaker/room combination that allows for a flat sound field at the ear of the listener.

Any sound recorded directly onto tape without reference to a 'live' original — such as much pop music and most electronic music — should also be given the best chance of reaching the ear of the listener with this same kind of accuracy. In such a case, the sounds represented by the record or tape will be accurately reproduced, and the only deviation from the musical intention of performer or producer will be those imposed by any aberrations that may have been present in the equipment used to monitor the original.

The AR-10π
Uniformly dispersed flat energy response begins with a speaker system's ability to radiate sound at all frequencies evenly in all directions. For low-frequency sounds this problem of dispersion is not of practical consequence, since they are very nearly omnidirectional. The limiting factor at higher frequencies is that a speaker will begin to be directional when its circumference equals the wavelength of the frequency being reproduced. Directionality increases as the wavelength decreases with respect to the speaker's dimensions. The laws of physics thereby dictate the most direct approach to the problem of even dispersion of high frequency energy: the drivers used must be made as small as possible. The dome midrange and tweeter units made by AR have been designed according to this principle in order to use these physical laws to the listener's advantage, since even dispersion of sound energy means that the sound of musical instruments on the recording will sound the same for listeners in all parts of the room.

One difficulty in designing small tweeter units is to maintain sufficient sound level without distortion or danger of damage to the drivers. Now, in order to make the AR-10π speaker system possible, AR has developed a new dome tweeter that offers maximum efficiency and smoothness of response. This new tweeter measures ¾ inches across its dome (about the size of a thumbnail) and therefore provides very nearly optimum dispersion to the upper limit of the audio range. New materials and proprietary construction techniques offer reduced distortion and improved transient response. A low resonance frequency (well below the crossover point) also contributes to the reduction in distortion, in addition to making the increased sensitivity usable in a system.

The development of the new AR-10π dome tweeter means that the energy capability of AR speaker systems at the highest audible frequencies can be brought into line with that of the woofer. This can be accomplished without sacrificing system efficiency (it has actually been increased), without using multiple high-frequency drivers, and without putting the single tweeter in increased danger of thermal damage. The result is a speaker designed for home use with flat energy capability that is able to accurately transmit the complex sound of a musical instrument to listeners in most locations within a room.

It also incorporates the flexibility to deliver this flat response under a great variety of conditions of use

Effects of speaker placement

The new tweeter developed for the AR-10π makes it possible to properly balance high- and low-frequency energy. The next problem to be solved is how to maintain this optimum balance under a variety of real conditions of use. The effect of room placement on the level of low-frequency energy is of primary importance in this respect. Any serious attempt to produce a flat sound field at the ear of the listener must therefore account for the listening room as part of the playback 'system'.

The basic problem to be overcome is that a speaker system radiates bass energy more effectively when placed in a corner than when placed along one wall. Likewise, more bass energy is produced when the speaker is placed along a wall than when it is placed well away from all room surfaces (as when placed on a stand away from the wall).It is immediately apparent that moving a speaker from one type of location to another will upset the balance of high- and low-frequency energy.

The conditions described above are generally spoken of in terms of the 'solid angle' into which the speaker is said to be radiating. These three basic solid angles are a quarter-sphere (equivalent to corner placement), a hemisphere (along one wall), and a full sphere (away from all room surfaces). They are described geometrically as 'π steradians', '2π steradians', and '4π steradians' respectively.

The first question that a speaker designer must therefore decide is in what type of room position the speaker is likely to be used. The common approach is then to design a speaker system to operate satisfactorily in the chosen type of position.

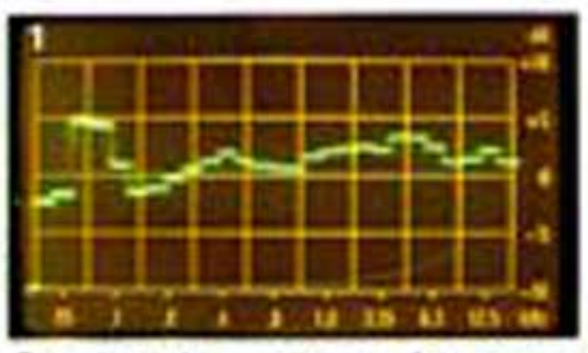
Most conventional speaker systems are 2π types. That is, they produce the intended result only when placed against the middle of a wall, preferably with books or other objects placed flush with their front panels. If such a speaker is placed in a corner, the results are almost always bass-heavy. If it is placed nearer the middle of a room, bass will be lacking.

The physical laws governing these effects are well known to speaker engineers, and it is possible to choose any of the three basic positions and design a speaker accordingly. But it is also possible to design into one speaker system a means of compensating for all three positions. This is the approach that AR has taken in the design of the AR-10π.

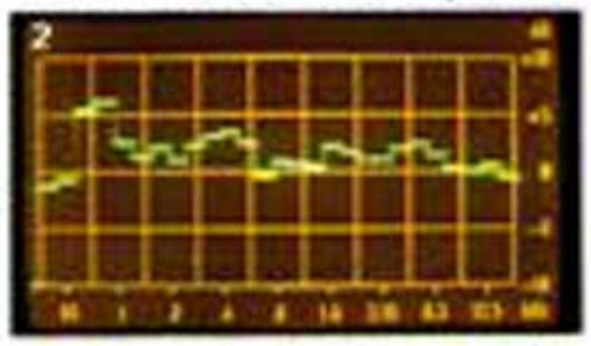
A 'Woofer Environmental Control' switch on the front panel of the AR-10π has three positions, corresponding to π, 2π, and 4π speaker placement. It provides the proper relative level of bass energy for each type of room positioning. In addition to altering the level of bass energy, the switch also alters the slope of the woofer's response in the crossover region in order to preserve flat energy response. The degree of precision required to achieve this form of compensation is not possible using available equalization techniques.

As an illustration of the increased flexibility of the AR-10π over other speaker designs, the graphs below show energy response from a single microphone position (or listening position) in one particular listening room.

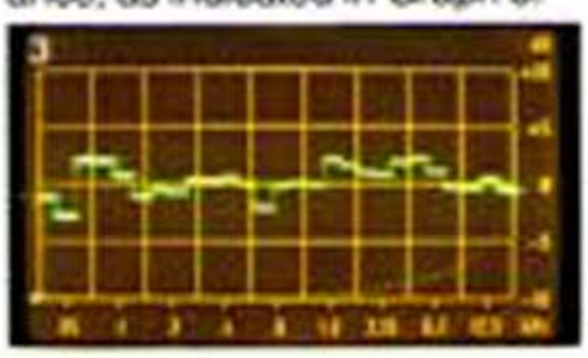
(While the curves are not as tidy as those normally published for loudspeakers, it must be borne in mind that they represent the energy performance of the speaker *in an actual listening room*. Considered on this basis, they are really quite remarkable.)

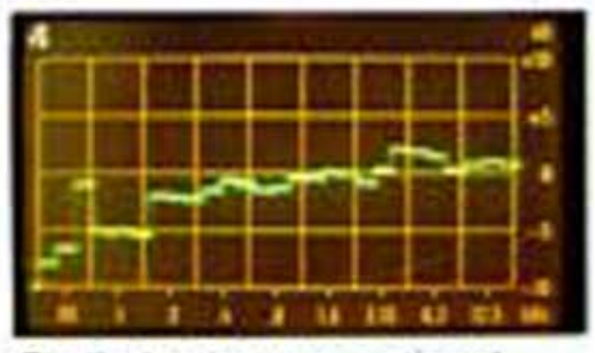


Graph 1 shows the performance of the AR-10π when placed against one wall of the room. The balance of high- and low-frequency energy represents the results that could be expected from a high quality loudspeaker designed for 2π operation. However, moving the speaker to a position on the floor, with its back still against the wall, gives the results shown in Graph 2.

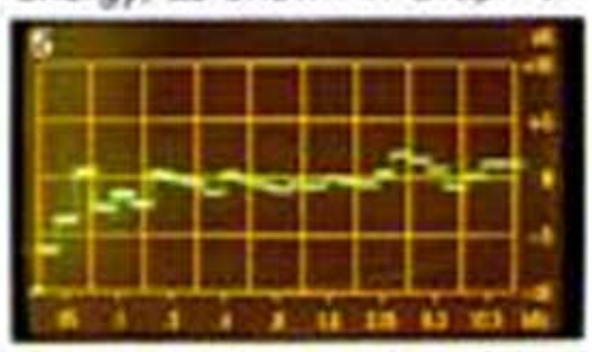


Note that the average level of bass energy is significantly increased with respect to that of the high frequencies. Simply switching the AR-10π Woofer Environmental Control to the π position restores the proper balance, as indicated in Graph 3.





Similarly, the conventional speaker would be expected to give the results shown in Graph 4 if it were to be placed at a significant distance from all room surfaces. Switching the AR-10π to its 4π setting restores accurate balance by increasing the level of low-frequency energy, as shown in Graph 5.



The appropriate setting of the Woofer Environmental Control provides the proper spectral balance of the AR-10π in the three basic types of room positions normally used for loudspeakers in the home. The appropriate musical balance can thus be maintained when the speaker is placed in any of these positions.

Two significantly different speaker placements in the same room. The positioning of the left-channel AR-10π approximates 2π because of the speaker's proximity to the left wall and window. The AR-10π on the right, however, was found to give best results in the 4π mode, because of its distance from all room surfaces. The Woofer Environmental Control makes compromise or repositioning unnecessary.

Other controls
Two 3-position switches, located next to the Woofer Environmental Control, provide a means of attenuating midrange and highrange drivers in 3dB steps. These switches are useful for restoring natural musical balance to some types of recordings or to compensate for the effects of over-reverberant listening environments. They can, of course, be used in conjunction with the Woofer Environmental Control and amplifier tone controls for an extremely fine degree of control over musical balance.

The AR-10π is designed to reproduce music in the home as accurately as the state of the art permits. Its ability in this respect represents a number of significant evolutionary improvements over previous designs. Further, the AR-10π is intended to offer an unprecedented degree of flexibility without any sacrifice in accuracy. The combination of these characteristics, we believe, represents a significant step forward in loudspeaker design.

Specifications
Drive units: 305 mm (12 in) acoustic suspension woofer, 38 mm (1½ in) hemispherical dome midrange, 19 mm (¾ in) hemispherical dome highrange
Crossover frequencies: 525Hz, 5000Hz
Impedance: 4 to 16 ohms nominal, depending on switch positions; highest impedance in π and −6dB switch positions, lowest in 4π and 0dB positions
Controls: Three 3-position switches for woofer environmental control and for midrange and highrange level control
Efficiency: 1 watt will produce 86dB SPL on axis at 1 meter
Amplifier power requirement: 25 watts (into one speaker only) will produce 100 dB SPL in a 3000 cu ft room of average reflectivity (energy absorption coefficient of 0.15), 50 watts (25 watts per channel) will produce 103dB SPL in the same room
Power-handling ability: May be used with amplifiers capable of delivering up to 150 watts continuous power per channel being driven to clipping 10 percent of the time, on normal musical source material
Crossover network: Half-section LC network on each driver using air core chokes and computer grade electrolytic capacitors; acoustic output of midrange and highrange drivers as well as the normalizing of woofer output for the three basic environments is accomplished via an autotransformer and individual switching networks
Driver resonance frequencies: Woofer 18Hz (free air), midrange 400Hz, highrange 2000Hz
System resonance frequency: 42Hz
Effective system Q: 0.7
Total flux: Woofer 200,000 maxwells, midrange 70,000 maxwells, highrange 21,000 maxwells
Flux density: Wooler 9,800 gauss, midrange 13,000 gauss, highrange 18,000 gauss
Volume of enclosure: 41.9 liters (1.48 cu ft)
Cabinet dimensions: 354 x 635 x 273 mm deep (13 15/16 x 25 x 10¾ in)
Weight: Packed in carton 27.1 kg (59¾ lb), unpacked 24.9 kg (55 lb)

Guarantee: The workmanship and performance in normal use of the AR-10π are guaranteed for five years from the date of purchase. This guarantee covers parts, repair labor, and freight costs to and from the factory or nearest authorized service station. New packaging if needed is also free. The guarantee is valid worldwide.

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