# PROJECT ARRAY™

TECHNICAL WHITE PAPER

JBL®

## INTRODUCTION

PROJECT ARRAY™ IS A SERIES OF HIGH-PERFORMANCE LOUDSPEAKERS UTILIZING COMPRESSION DRIVER TECHNOLOGY FOR HOME MUSIC REPRODUCTION. THE SYSTEMS ARE DESIGNED TO COMBINE THE SPEED, DYNAMICS AND EFFORTLESSNESS OF JBL® COMPRESSION DRIVER SYSTEMS WITH THE THREE-DIMENSIONAL SOUNDSTAGE OF THE VERY BEST HIGH-END DIRECT-RADIATOR SYSTEM.

A major consideration for high-quality system design is uniformity of acoustical power radiation from the loudspeaker into the listening space. There are two aspects here: smooth on-axis response and controlled vertical and horizontal radiation coverage. Studies carried out by various technical groups within the Harman organization have shown a universal preference on the part of professionals and critical consumers for loudspeakers that exhibit such uniformity.

The current emphasis on home theater playback systems has resulted in an ever-stronger demand from critical listeners for lower distortion in their loudspeaker systems. The often high playback levels desired for movie or concert video programming make low distortion a key element in avoiding listener fatigue. While there may be several approaches to achieving bandwidth extension and uniform power response, there remains only one way to ensure high playback levels with high dynamic linearity – and that is through the use of carefully designed transducers that are capable of undistorted output levels many times greater than will normally be required of them. Compression drivers are ideal for these applications, but are expensive to build. They have a large number of critical internal parts requiring extremely tight tolerances. The drivers used in Project Array speakers embody the design and quality level of those used in professional studio monitors and sound reinforcement systems. They have been optimized for smooth, extended response, which is essential for maximum quality music playback.

In critical loudspeaker auditioning sessions, listeners become very aware of subtle timbral and spatial aspects which are often difficult to measure. Such matters as cone materials, high-frequency diaphragm materials and dividing-network component integrity become important design considerations in defining a modern state-of-the-art loudspeaker system.

## SYSTEM

Compression driver systems have long been known for their clarity, speed and dynamic capabilities. They have an effortless character that sets them apart from traditional direct-radiator systems. However, there traditionally has been a "closed in" feel to the soundstage produced by many horn systems. Since horns tend to be large, they are generally included within the main enclosure and are often surrounded by a lot of baffling. Many of the best-sounding direct-radiator systems have minimal baffle areas, particularly around the mid- and high-frequency drivers. This is the major concept behind Project Array. The horn has been oriented to minimize width and to position the diffraction slot within the horn in the vertical plane. Although the Bi-Radial® horn has good dispersion in both planes, it has the smoothest behavior with the slot mounted vertically. Next, the top of the LF enclosure has been cut away so that the horn is nearly freestanding. The horn enclosure is minimal and heavily windswept, to minimize baffle area. The final major feature is the ability of the horn to be moved forward or backward without creating baffle discontinuities. This allows the horn HF and LF driver to be lined up in the depth direction to achieve the best time behavior over a large frequency range. This also allows the drivers to be "in polarity" in addition to being "in phase" at the crossover point. The sum total of these main features amounts to a loudspeaker system with the speed and dynamics of a compression driver system, yet with the smoothness and imaging of the best direct-radiator and panel systems.

## 2-CHANNEL VS. MULTICHANNEL

A good loudspeaker is a good loudspeaker. A properly designed and constructed loudspeaker system should be able to do a credible job when used singly, in pairs or in a multichannel application. With that said, there are a few specific requirements for home theater usage that can interfere with ideal two-channel operation. The first is output level. Home theater systems are often played at pretty extreme levels that can exceed the design parameters of high-quality "stereo" systems. Simply beefing up a traditional system can lead to losses in detail and subtleties. JBL's use of compression drivers for much of the mid- and high-frequency range eliminates this problem. A good compression driver has an operating efficiency of up to 25% – 30% compared to 1% or less for almost all direct radiators. This means that they never experience more than a few watts of driving signal even at extremely high playback levels. Consequently, they are always operating in their linear range and don't contribute to dynamic distortion and listening fatigue.

The second requirement of home theater applications comes from the need for five, six or even seven individual loudspeakers to make up the total system. Ideally, all channels should use an identical speaker system, plus one or more subwoofer channels. This very often is not feasible for both cost and space reasons. Project Array comprises five models: one subwoofer, one dedicated center channel and three full-range loudspeakers. Tremendous care has been taken to match key parameters of the 800, 880, 1000 and 1400 so that it is possible to mix models within a total system and still maintain proper decoding of the complex sound matrix presented by high-quality source material (Fig. 1).

Matching the on-axis frequency response of the individual speaker models is a good start, but is not sufficient to guarantee timbre match. It is also necessary that the directivity and sound power of the systems match. This is quite a challenge with four different shapes and sizes, three different horn and driver combinations, and four different woofer drivers. Note the consistency of frequency and power response between the models (Fig. 2). Finally, timbre match is not the single most important criterion for proper decoding of a large multichannel matrix. The phase and polarity characteristics of the systems must also be as identical as possible. It is well known that a proper stereo soundstage, including a well-defined phantom center, is not likely if the left and right speakers are not matched. In a multichannel playback system, a "phantom channel" opportunity exists between each real speaker pair. If all of the speakers are not completely balanced, the three-dimensional sound space will have voids, or gaps, when there is movement in the sound locations.

## ENCLOSURES

The woofer enclosures for all five systems are constructed of medium density fiberboard, chosen for its significant weight and good internal damping characteristics. In the case of the 1400, the baffle and back are 1" thick and the sides are 1-1/2". The side panels for each enclosure are milled to give the curved outer surface. As a result, the panels are much thicker in the middle than at the edges, and the internal cross section of the enclosure is a trapezoid. The variable wall thickness and nonrectangular internal dimensions contribute to good resonance damping and minimized internal standing wave buildup. The tops of the enclosures have a very elaborate construction, and are very securely joined to the main body to provide mechanical stability to the shape and provide a solid mounting reference for the horn modules.

The horns are compression-molded from SonoGlass® under significant temperature and the force of a 200-ton press. The resulting form is very dense and inert. The horn housing is molded in a structural foam material that provides a smooth acoustic shell for the horn/driver combination and conceals the mechanical internal components. Each horn module contains one of two HF compression drivers used in Project Array and a separate UHF compression driver.

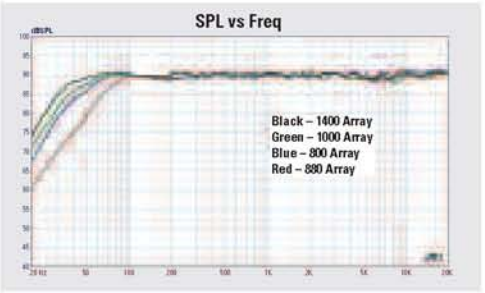


**Figure 1 – On-axis response of four Array systems level matched to 90dB SPL.**

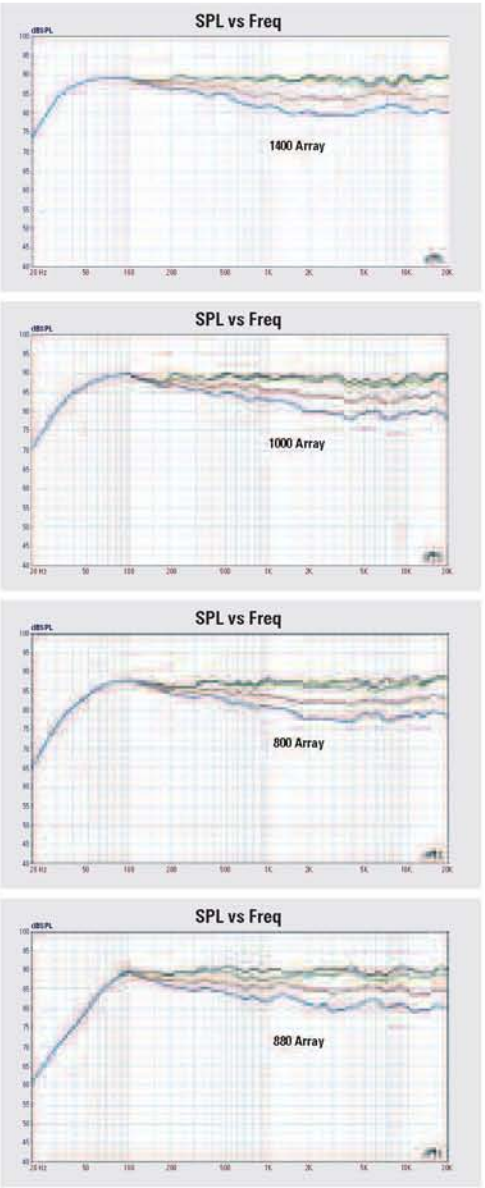


**Figure 2 – Power response measurements on four Array models. The black curve is the on-axis response, the green curve is the averaged listening-window response and the red curve is the averaged response of the first reflections, while the blue curve is the total power response.**

**Figure 3 – LE14H-3 low-frequency driver.**

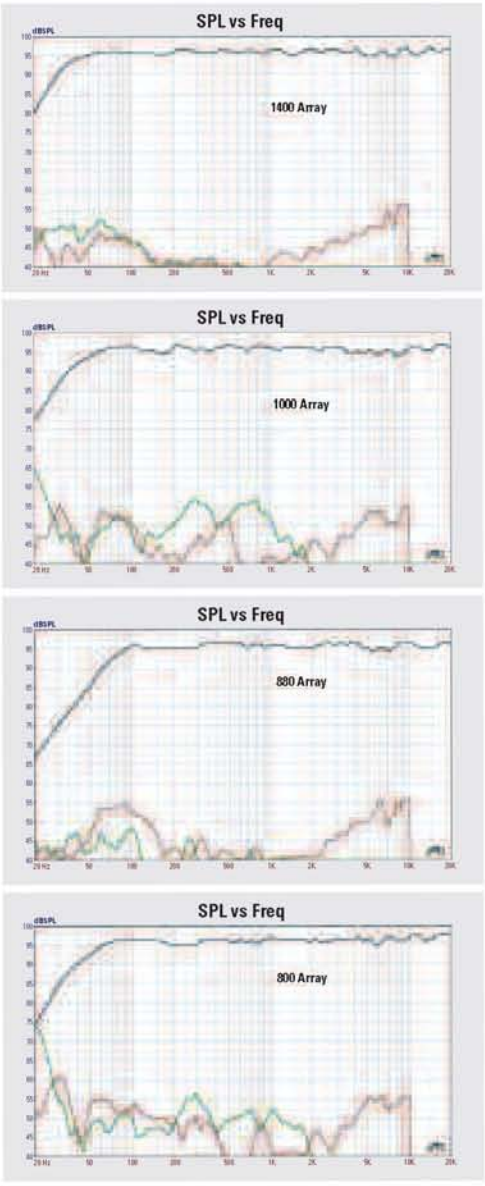


**Figure 4 – Second and third harmonic distortion products with the systems driven to 96dB SPL at 1 meter; 0.3% harmonic distortion is equivalent to 50dB below the on-axis curve, and 1% is –40dB.**

## TRANSDUCERS

### LOW-FREQUENCY DRIVERS:

There are five unique low-frequency drivers employed in the Project Array models. The design and parameters of each are specific to the speaker's application. There is a careful balance between enclosure size, sensitivity and low-frequency extension for each model.

The W1500H driver is a 15"-diameter device with a 4" edge-wound voice coil and is used in the 1500 Array powered subwoofer. It has a 1-13/16"-long coil in a 1/2"-thick magnetic gap. A fully vented frame and motor structure is used for minimizing acoustic losses and for cooling of internal parts through optimal transfer of air into and out of the magnetic structure. This gives both superior linearity and excellent heatsinking, which are necessary to preventing dynamic compression.

The 1400 Array uses the LE14H-3 low-frequency driver. It is a 14"-diameter woofer with a 4" edge-wound voice coil. This model has a felted paper cone that is heavily treated with Aquaplas on both the front and back sides of the cone. This makes a diaphragm assembly which is very stiff and totally inert. As a result, the midband distortion of this driver is extremely low (Fig. 3).

All of the low-frequency drivers in Project Array share traditional JBL design features which set them apart from typical mass-produced units. Each of them uses a cast-aluminum frame, Symmetrical Field Geometry™ (SFG™), an aluminum flux-stabilization ring, optimized high-efficiency magnetic gaps and vented magnetic assemblies. These features combine to give the great dynamic performance and low distortion required by today's highly active source materials (Fig. 4).

### HIGH-FREQUENCY DRIVERS AND HORNS:

The 1400 Array and 880 Array use the 435Al-1 compression driver. It makes use of a 3"-diameter aluminum diaphragm operating into an annular-slit phasing plug. The dome is coated with a fine layer of Aquaplas for damping of spurious resonances. The use of neodymium magnetic material keeps the size of the driver to a minimum. The phasing plug and initial-flare development are of the rapid-flare type that reduces second harmonic distortion by up to 6dB relative to JBL's earlier driver technology (Fig. 5). The average midband sensitivity of the 435Al-1 on an Array horn is 114dB SPL for a 2.83V input at 1 meter. Approximately 24dB of attenuation is used to match the horn/driver level with that of the low-frequency transducer. This is the reason for the tremendous headroom in the Array systems.

The 800 and 1000 models use a 175Nd-3 compression driver. It contains a 1-3/4"-diameter titanium diaphragm that is also Aquaplas-coated. This driver also uses a neodymium magnetic circuit and an annular-slit phasing plug. The average sensitivity of the 175Nd-3 is 110dB SPL for a 2.83V input at 1 meter. This still results in around 20dB of attenuation relative to the woofer sections of the 800 and 1000 Array.

The large Bi-Radial horn used on the 1400 Array has a basic coverage pattern of 80° horizontal by 80° vertical. It provides proper loading to the 435Al-3 driver down to the 750Hz crossover point. A smaller Bi-Radial horn is used in the 800, 880 and 1000 Array systems. It too has a basic 80°-by-80° pattern, and allows crossover points of 900Hz and above. In order to maintain similar sound power characteristics between the various systems, the crossover frequency must be incrementally higher for systems with smaller-diameter low-frequency drivers.

### ULTRAHIGH-FREQUENCY DRIVER AND HORN:

The 045Ti UHF is the smallest compression driver that JBL has ever built. It uses a 1" titanium diaphragm in a 2" neodymium magnetic structure. The single-layer, aluminum-ribbon voice coil is wound without a former and is attached directly to the diaphragm. The driver also employs the smallest annular-slit phasing plug that JBL has ever designed. The extremely low mass of the moving system, high magnetic-flux density and rigidity of the diaphragm assembly produce high sensitivity and response beyond 40kHz (Fig. 6).

The UHF horn is properly scaled to maintain a coverage angle of 60° in the horizontal plane and 30° in the vertical plane over the interval from 8kHz to 40kHz. It has been integrated into the top vertical wall of the main horn for best coverage and imaging.

## COMPONENT INTEGRATION

It is all well and good to have the finest transducers and enclosures, but without proper integration, they are only a group of raw parts. The dividing network is like a conductor for a fine orchestra. Its function is to divide the frequency spectrum and direct the parts to the appropriate driver. The network design for all four systems is necessarily very similar. This allows the completed systems to sound as identical as possible. The circuit topology, combined with the acoustic behavior of the individual transducers, provides 24dB-per-octave transitions between adjacent system elements. The response of each element is –6dB at the transition frequency. These rapid transitions provide more uniform system response over a larger vertical listening angle than that provided by lower-order slopes, and this translates into an increased solid listening angle for the system. Each network consists of frequency dividing, level attenuation and equalization functions. All of the electrical components are of the highest quality and lowest internal loss. The majority of the inductors used are air core so as to not introduce nonlinear hysteresis effects. Capacitors are constructed using polypropylene foil, which is known for having minimal distortion caused by dielectric absorption nonlinearities. Resistors are of wire-wound construction and are elevated on metal legs to permit significant airflow to reduce value shift during high-power operation. Every attempt is made to present as smooth a system impedance curve as possible to the driving amplifier. This design element is often overlooked in many loudspeaker systems. Amplifiers work their best when they are given a smooth, level load impedance in which to deliver current (Fig. 7).

The aggregate of these attributes allows the Project Array loudspeakers to translate the electrical signal from source material into an accurate and unencumbered three-dimensional sound field.

**Figure 5 – The 435Al-1 compression driver.**

**Figure 6 – The 045Ti-1 ultrahigh-compression driver.**

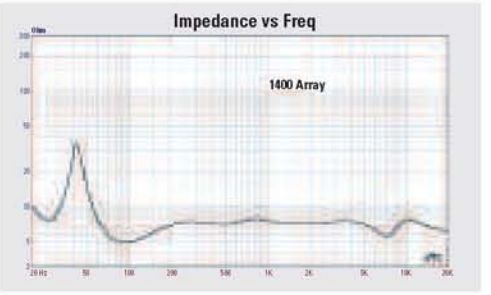


**Figure 7 – Magnitude of impedance for the 1400 Array system.**

**PRO SOUND COMES HOME™**

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