PROJECT EVEREST DD66000

TECHNICAL WHITE PAPER

®

INTRODUCTION

THE PROJECT EVEREST DD66000 LOUDSPEAKER SYSTEM IS A CELEBRATION OF JBL'S 60TH ANNIVERSARY. IT IS QUITE SIMPLY THE FINEST LOUDSPEAKER SYSTEM JBL HAS EVER DESIGNED AND MANUFACTURED.

The design goals were very straightforward in definition, but extremely difficult to accomplish. With a 60-year legacy of some of the finest loudspeaker systems ever produced, it was necessary to develop a system with an appearance that incorporated both traditional and modern elements, while producing the highest level of musical fidelity in our history.

The measured performance of the DD66000 is exemplary. The frequency response of the system is extremely smooth and extended. Directivity and power response are very uniform, harmonic distortion levels approach that of fine amplifiers, and the dynamic linearity of the system is unparalleled. However, we don't listen to measurements; we listen to music, and the DD66000 effortlessly reproduces the heart and soul of everything from baroque to reggae. Regardless of what style of music it is or what playback level is desired, the DD66000 is ready and able to deliver the most personal performance ever.

SYSTEM

The basic system configuration is what JBL has historically referred to as an augmented two-way. In the 1950's and 1960's, JBL primarily built two-way systems with a 12" or 15" woofer crossed over to a large-format compression driver/horn combination. Some of the systems would be "augmented" by a UHF device, most usually the 075 ring radiator that would operate above 8kHz. These systems would have only a single crossover point in the middle of the audio range, to minimize any sonic degradation caused by the dividing network. The DD66000 has a single midrange crossover at 700Hz, blending a 1501AL woofer to the 476Be compression driver and horn combination. The 045Be-1 UHF driver is brought in at 20kHz to cover an octave and a half of ultrasonic frequencies. A second 1501AL operates in the bass frequency range from below 30Hz to around 150Hz, where it is rolled off at a gradual 6dB/octave. The first-order slope ensures proper amplitude and phase summing between the two woofers over their total operating range. Both woofers operate below 150Hz, but only one of them extends up to the 700Hz crossover point. This is done to achieve proper directivity control throughout the entire woofer operating range, while delivering powerful and extended low-frequency performance. Above 700Hz, the HF compression driver and horn combination operates unassisted all the way to 20kHz (Fig. 1).

The transducers, horns and crossover networks are housed in a visually stunning enclosure that is reminiscent of both the Hartsfield and Paragon systems. The specially curved baffle provides the sidewalls for the main horn. The top and bottom horn flares are accomplished by the attachment of precision-molded SonoGlass® horn "lips" to the upper enclosure surface. A SonoGlass throat section is mounted inside the enclosure to provide the initial transition from the 38mm exit of the 476Be driver to the main horn section. The UHF driver is mounted to a SonoGlass horn, which is itself mounted to the back of the die-cast aluminum housing. This assembly mounts to the top of the enclosure, using a system of metal pins and rubber cups. This methodology provides proper alignment and a measure of mechanical isolation. All of the flat surfaces of the enclosure are 25mm MDF. The curved panels are made from two different thicknesses of grooved MDF and total 25mm combined. A proprietary process is utilized for creating the curved panels. Individual sheets of MDF are grooved to allow flexure and then locked into the proper radius with a backing material. Two different thicknesses of this curved MDF are then combined to form the final panel. These layers are both decoupled and extremely rigid. The voids between the grooves are filled with a foam/glue material after forming, which results in behavior much like that of double-layer glass (used to isolate exterior noise). The enclosure bracing is designed as a shaped form over which the curved panels are applied. The complex bracing is used to precisely hold the outer curved panels in exactly the correct shape, allowing exceptional fit and consistency. The woofer baffle module is a six-sided shell that is separately assembled and braced. It then slides into place, where its bracing and that of the main enclosure actually interlock to form an extremely rigid and secure final structure. A leather-covered outer baffle is then applied, giving the total combined woofer baffle a thickness of 45mm. The outer baffle is removable, should repair or replacement of the leather surface ever be necessary.

The system is ported on the rear with a tuning frequency of 34Hz. Two 100mm-diameter flared ports are combined with the input connections on a massive three-piece, die-cast aluminum structure. The entire enclosure rests on four stainless-steel-foot assemblies. Stainless-steel coasters are included to protect wood and tile floors from damage from the spike feet. The grille assembly is constructed of MDF and uses a thick, perforated metal sheet to provide the curved shape. The grille is joined to the

enclosure with metal pins and rubber cups. The 1501AL and 476Be are both designed to be absolute minimum-distortion drive units. Although they are capable of tremendous acoustic output, their design intent is to be completely linear in every way, up to a reasonable drive level. Within this operating range, there are no appreciable changes in any measured parameter of the system. This enables the system to sound the same, regardless of playback level (Fig. 2).

TRANSDUCERS

1501AL LOW-FREQUENCY DRIVER

The 1501AL low-frequency driver was designed by Jerry Moro, senior development engineer for Harman Consumer Group. It is very similar to the 1500AL used in the S9800 system. It incorporates a new high-impedance voice coil to allow a pair of woofers to be used while still maintaining an 8-ohm system impedance. The voice-coil length has been increased to 30.5mm (from 20.3mm) and its milling width has been reduced slightly. This was done to allow greater clearance from the outer diameter of the coil to the laminated top plate, and to provide a larger area of coil surface for heat dissipation. These coil improvements allow the 1501AL to handle up to 25% more power than the 1500AL.

The 1501AL LF driver is a 380mm-diameter device with a 100mm voice coil completely immersed in a radial field generated by an Alnico 5DG magnet. Alnico was chosen because of its stable operating point. This material is insensitive to temperature changes and back-EMF from the coil. JBL has overcome the tendency of Alnico to demagnetize with high drive by utilizing a massive shorting ring at the base of the motor assembly. The top plate is constructed of alternating copper-steel laminations. The presence of the copper rings linearizes the magnetic properties of the gap to all but eliminate eddy current distortion. The total gap is 41mm long and provides a completely uniform flux field for the voice coil. Another benefit of this construction method is that the voice-coil inductance remains essentially constant over the operating range of the driver. This means that the load presented to the crossover network and ultimately to the driving amplifier is uniform with coil position. This eliminates yet another source of dynamic distortion – inductance modulation, which is prevalent in many inferior drivers.

The outer suspension is made of EPDM foamed rubber, which has the longevity and frequency response characteristics of traditional rubber surrounds, but with a low density very close to that of foam surrounds. Low-loss EPDM material was chosen so that the transient detail of musical signals could be preserved. Dual inverted Nomex® spiders are employed for the cancellation of even-order distortion components. All suspension elements are tailored for maximum mechanical displacement linearity.

The cone comprises a special layered paper-pulp matrix with proprietary Aquaplas damping, which offers more pistonic behavior throughout the woofer's operating bandwidth, and controlled cone breakup beyond it.

A thick-wall, cast-aluminum frame is used to rigidly support the 16kg motor structure. It was designed to offer this support yet remain acoustically open to the rear of the cone and spider, in order to minimize acoustic compression. Besides cooling, this fully vented frame and motor design also serves to minimize the back-pressure under the dome and spider, which helps to reduce harmonic distortion to even lower levels. JBL's Vented Gap Cooling™ (VGC) is incorporated within the motor structure. Air, pumped by the dome, is forced directly past the coil, and "exhausted" out the three pole vents in the rear of the structure. This forced convection cooling helps to lower the operating temperature of the coil during moments of high power operation. The Alnico motor structure is pressed into a special magnetic heatsink/cover designed to increase the thermal radiating area, which helps draw heat away to surrounding air. Additional vents around the circumference of the cover assist the pumping action of the spiders for additional air circulation.

Altogether, these design factors provide reduced harmonic distortions at very low and high acoustic output, improved power handling, reduced power compression, and more consistent spectral balance, with varying input drive level.

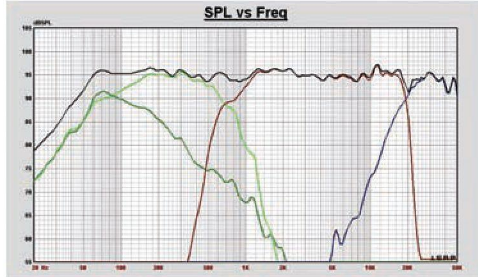

Figure 1 – On-axis response of the DD66000 system and that of each of the transducers through its crossover network (2.83V @ 1m).

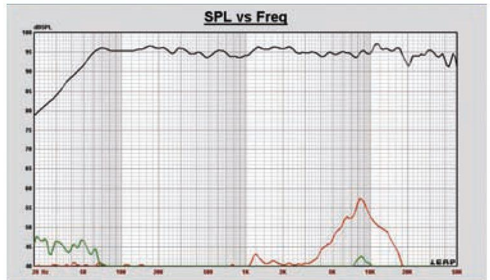

Figure 2 – Second and third harmonic distortion products with the system driven to 96dB SPL at 1 meter; 0.3% harmonic distortion is equivalent to 50dB below the on-axis curve.

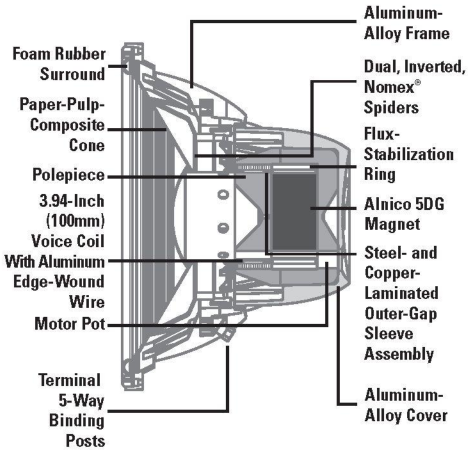

Figure 3 – 1501AL section view.

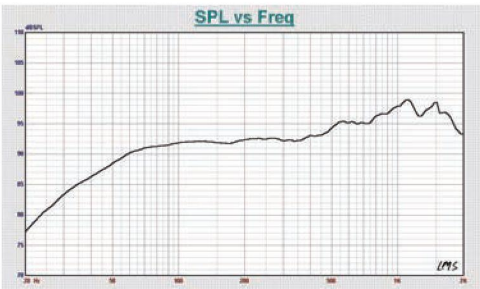

Figure 4 – 1501AL half-space frequency response measured in a 19-cubic-foot test enclosure. The measurement was made with 2.83V at 1m.

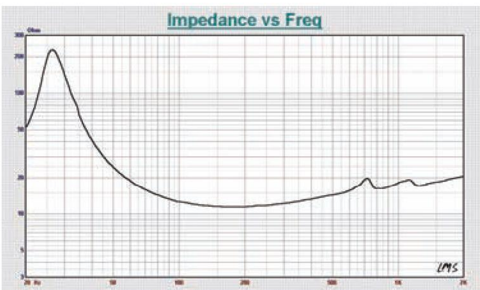

Figure 5 – Impedance curve of 1501AL in free air.

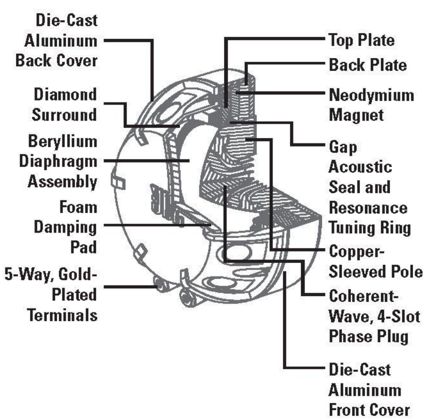

Figure 6 – 476Be section view.

Pertinent mechanical, magnetic and acoustical parameters of the 1501AL LF driver are:

Flux density: 0.52 tesla throughout the 40.64mm-long gap

BL product: 27 T•m

Voice-coil resistance: 9.2 ohms

Voice-coil winding length: 30.5mm

Free-air resonance frequency: 27Hz

Peak-to-peak linear excursion capability: 25.4mm

Weight of magnetic structure: 13.6kg (without cover)

Driver sensitivity (2.83V @ 1m): 92dB SPL

476BE HIGH-FREQUENCY DRIVER AND HORN

The 476Be high-frequency compression driver was also designed by our own Jerry Moro. It makes use of a 100mm-diameter, pure-beryllium diaphragm with a 99mm aluminum edge-wound coil, operating into JBL's existing rapid-flare-type, coherent-wave phasing plug. The use of an efficient, neodymium, rare-earth motor structure with new copper-sleeved polepiece maintains maximum gap flux and reduced coil inductance at a minimum size and weight. The combination of these features yields a driver that can deliver superior sound quality, regardless of acoustic power output, with very little distortion and power compression (Fig. 6).

The 476Be motor structure incorporates the following key features:

- A pressed-on, 0.23mm-thick, high-purity, copper-sleeved polepiece is used instead of a conventional copper "plated" pole. This technique is used to greatly improve the electrical conductivity of the copper sleeve for lower coil inductance and thus greater high-frequency output at 15kHz and above. To improve high-frequency output and sound quality even further, the copper sleeve also greatly minimizes the losses and distortions due to eddy currents in the polepiece. Another benefit of the copper-sleeved pole is the ability of the copper to quickly wick away heat generated by the coil. To further enhance or maximize this efficient heat transfer from the coil to the entire polepiece, the length of the copper sleeve was extended to 13.7mm, for more than four times the area of the coil. This results in the reduction of short-term, dynamic power compression.
- Neodymium, rare-earth magnet material is used in an "outer ring" configuration formed of eight individual arc-segments. This configuration creates a very large diameter and magnet area for a moderate cost, when compared to a one-piece ring design of the same size. To compensate for the higher reluctance gap caused by the use of a copper-sleeved polepiece, a large magnet area was used in conjunction with special high-grade and high-temperature-grade neodymium. This allows the motor design to maintain a minimum gap-flux density of approximately 18,000 gauss.
- Special acoustic vents are machined into the top plate, directly under the diamond surround, to properly control the surround chamber resonances. A filler and an acoustic seal are also used in the magnetic gap for similar reasons. Acoustic tuning of these cavity resonances throughout the design – especially in the magnetic gap and under the diaphragm's surround – is necessary to maintain smoothness of the mid-band frequency response.
- The phasing plug is of JBL's traditional rapid-flare, coherent-wave, four-slot design. It is precision-die-cast out of zinc material, which is used to ensure dimensional and structural stability while under high thermal and acoustic pressure loads. The phase relationship of the sound emitted from various areas of the 100mm diaphragm is controlled as it passes through the four slots of the phase plug toward the 38mm exit. This coherent-wave design shapes the wave output, producing a truly coincident wave front as the sound enters the horn. When used in conjunction with optimized Bi-Radial® horn designs, the coherent-wave and rapid-flare phase plug offers smooth frequency response and up to 6dB lower 2nd harmonic distortion, relative to JBL's earlier driver technology.

The major features of the 476Be diaphragm assembly are as follows:

- The diaphragm is formed of pure-beryllium foil and is the first JBL large-format, 100mm compression driver to use this special material. A proprietary, high-temperature and pressure-forming process is used to form the extremely thin sheets of pure beryllium into the 100mm diaphragm shape. This new process even enables the integrated JBL diamond surround to be formed as one piece with the dome. Compared to other methods, forming the diaphragms out of sheets of beryllium foil yields greater reliability and resistance against failures due to fatigue. If breakage ever does occur, the diaphragm is more likely to simply tear rather than shatter into pieces or harmful dust.
- Beryllium's very high Young's modulus and very low density create a stiffness-to-density ratio of 15,200cm/sec, about five times that of aluminum, magnesium, titanium and iron. This high Young's modulus allows the 100mm beryllium dome to be only 0.05mm thick and yet still maintain pistonic behavior up to 20,000Hz. This eliminates diaphragm modal breakup and keeps the upper frequency response very smooth, with minimal distortion spikes.
- Achieving extremely low-moving mass was another benefit of beryllium's low density. The 0.05mm-thick material for the diaphragm and integral diamond surround, combined with JBL's low-mass, aluminum edge-wound coil, gives the overall diaphragm assembly a moving mass of only 2.1 grams. Compared to the 475Nd compression driver used in JBL's original K2 S9500 and M9500 systems, this is about a 45% reduction in moving mass (Mms). With such a low mass, the moving assembly is able to respond even more quickly to musical transients to further enhance detail and microdynamic nuances.
- JBL's diamond-pattern surround is utilized to maintain proper control and tuning of the second diaphragm resonance (the surround resonance mode). The proper control and placement of this surround resonance are critical for good high-frequency shape, extension and level. Conventional "flat"- or "half-roll"-type beryllium surrounds would have placed this surround resonance at too low a frequency to give optimal high-frequency roll-off characteristics.

These features, taken as a whole, create a new large-format compression driver with the greatest high-frequency extension, lowest distortion, smoothest response and greatest sonic detail of any ever produced by JBL (Figures 7 and 8).

Pertinent parameters of the 476Be HF driver are:

Voice-coil DCR resistance: 8.0 ohms

Voice-coil winding length: 3.25mm

Mass of moving system: 2.1g

Impedance: 12.0 ohms (minimum)

Flux density: 1.8 tesla throughout the 3.17mm-long gap

BL product: 17.0 T•m

Sensitivity (2.83V @ 1m): 110dB measured on DD66000 horn

Weight: 4.85kg

045BE-1 ULTRAHIGH-FREQUENCY DRIVER AND HORN

Like the 045Be, the 045Be-1 uses a 25mm beryllium diaphragm and 50mm neodymium magnetic structure. The pure-beryllium diaphragm is less than 0.04mm thick and has a mass of only 0.1 gram. The single-layer aluminum ribbon voice coil is wound without a former and attached directly to the diaphragm. The driver employs the smallest annular slit phasing plug that JBL has ever designed. Each phasing plug assembly is manufactured by modern stereo lithography techniques for absolute dimensional integrity. The 045Be-1 has been redesigned to improve manufacturing yield and consistency. Small changes have been made to the top plate and significant improvements were made to the surround shape and clamping methodology. As a result, the driver has picked up nearly 5dB of increased output above 30kHz. A section view of the 045Be-1 driver is shown in Figure 9.

The extremely low mass of the moving system, high magnetic-flux density and the high rigidity of beryllium produce response that is very smooth from below 8kHz to beyond 50kHz, as seen in Figure 10.

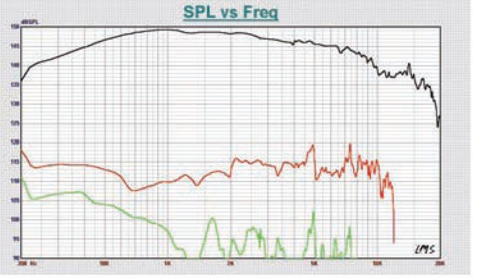

Figure 7 – Terminated tube measurement of 476Be with distortion products. The measurement was made with 7.5V applied to the driver. This equates to about 120dB at 1m when mounted in the system.

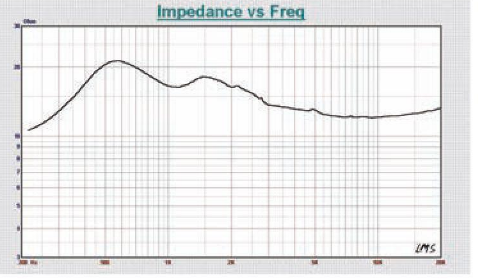

Figure 8 – Impedance curve of 476Be on a terminated tube.

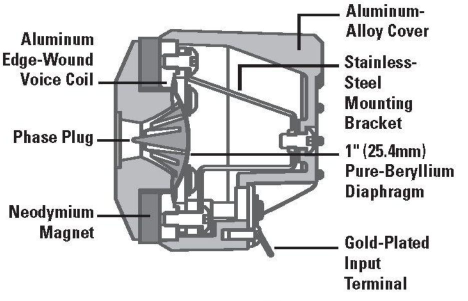

Figure 9 – Section view of 045Be-1.

Figure 10 – 045Be-1 response, 2.83V at 1m measured on DD66000 UHF horn.

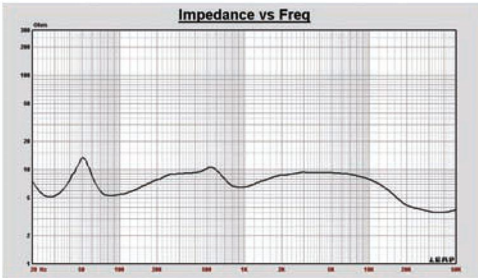

Figure 11 – Magnitude of impedance for the DD66000 system. Notice that the impedance remains between 5 ohms and 10 ohms throughout the majority of the audio band.

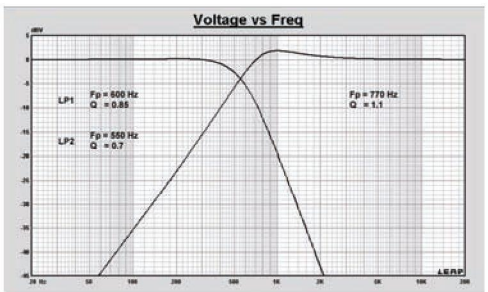

Figure 12 – Low-pass and high-pass curves are required for the use of an external dividing network to bi-amplify the DD66000 system.

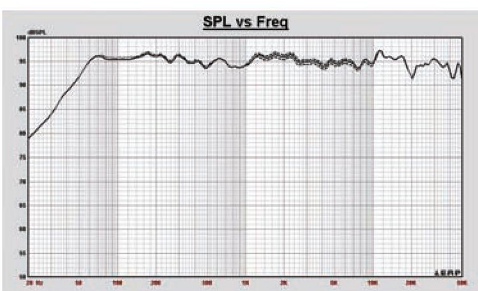

Figure 13 – Response changes due to HF Level and LF1 and LF2 shorting bars.

The response curve has a slight downhill tilt due to the constant-directivity nature of the horn used in this system. The horn is properly scaled to maintain a coverage angle of 60 degrees in the horizontal plane and 30 degrees in the vertical plane over the frequency interval from 10kHz to 50kHz.

Pertinent magnetic and acoustical details:

Mass of moving system: 0.3g

Flux density in gap: 20 tesla (20kg)

Magnetic assembly weight: 0.21kg

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. It is the function of the crossover network to divide the frequency spectrum and direct the parts to the appropriate driver. When done properly, the resulting sound quality takes on life as a performance, not just a sterile reconstruction of an electronic file.

The circuit topology – combined with the acoustic behavior of the 1501AL and 476Be – provides a 24dB-per-octave transition at 700Hz. This is the primary crossover point of the system. Additionally, the 045Be-1 is turned on above 20kHz, to provide extended response to beyond 50kHz. A second 1501AL woofer is used from below 30Hz to about 150Hz, at which point it is gently rolled off at 6dB per octave. The design intent is to use both woofers in the bass frequencies and slowly transition to a single woofer in the midrange. This technique allows a primary crossover point between just two drivers and permits proper control of the directivity pattern of the system, while providing tremendous power and air movement capabilities at the lower frequencies. As a result, the speed and power of the DD66000 system is unmatched from the lowest to the highest frequencies. The crossover network comprises four individual boards – one for each transducer. They are separated within the enclosure to minimize any potential crosstalk. Each crossover board has been optimized for the specific transducer and frequency range with which it is intended to operate. The low-frequency board is designed to pass large amounts of current in a linear manner. The midrange, high-frequency and ultrahigh-frequency boards have been designed for ultralow distortion and extremely linear behavior. All of the electrical components are of the highest quality and lowest internal loss. 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. The mid-, high- and ultrahigh-frequency networks employ battery bias to operate the capacitors effectively in a Class A mode. Low-frequency resistors are of wire-wound construction and are elevated on metal legs to permit significant airflow to minimize value shift during high-power operation. Resistors used on the mid-, high- and ultrahigh-frequency boards are of metal oxide construction. They have been chosen for their superior sonic characteristics and are used in multiples to minimize value shift during high drive conditions. Every attempt is made to present as smooth a system impedance 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. 11).

The aggregate of these attributes allows the DD66000 system to translate the electrical signal from source material into an accurate and unencumbered three-dimensional sound field. The system can do this at any desired listening level, from whisper-quiet to big-band loud, while at the same time maintaining unchanged acoustic characteristics.

CONTROL OPERATION

In addition to separate low-frequency and high-frequency input terminals on the rear input panel, the DD66000 system has two front-mounted control panels. These panels contain jumper bars, which allow for the selection of bi-amplification, woofer level trim, high-frequency level trim and woofer orientation. They also provide access to the 9-volt batteries used for capacitor bias. Selection of the bar position accomplishes the following adjustments:

LF Drive – Selection of the Bi-Amp position for the shorting bars bypasses the crossover function for the full-range woofer and the high-frequency driver. The low-frequency woofer and the ultrahigh-frequency drivers are unchanged. Use of this feature requires the addition of an external dividing network to provide the 700Hz primary crossover point for the system. The built-in attenuation and equalization for the 476Be remain in place. The high-frequency level trim remains operational, as does battery bias for both the low- and high-frequency sections. Normally, all three sets of bars (2-LF and 1-HF) would be moved together. It is possible to operate the system with just the low-frequency system or the high-frequency system set to Bi-Amp. In this circumstance, it would be necessary to use the combination of an external dividing network and the internal network. However, this would require some very special needs and is not generally recommended. Figure 12 shows the low-frequency and high-frequency voltage drive functions necessary to properly bi-amplify a DD66000 system using an external dividing network and two amplifier channels. Neither the low-pass nor high-pass drive is a standard Butterworth alignment or, for that matter, any standard alignment. The provided drive curves were derived using the internal passive network and resulting acoustic low-pass and high-pass shapes. Duplicating these shapes will result in the same frequency response and directivity pattern as a passive DD66000. The low pass is made up of two cascaded second-order sections and the high pass is a single high-pass section. The values within a high-quality analog dividing network can usually be modified to achieve these results. Recent digital crossover units will have no problem duplicating these curves.

LF Level – There is a level trim available for each of the two woofers (LF1 and LF2). Moving a bar from Low to High will increase the drive level to a portion of the frequency spectrum over which each woofer operates. LF1 refers to the low-range woofer (up to 150Hz) and will affect the output level in the range of 60Hz – 150Hz by about 0.5dB. LF2 refers to the main woofer and will affect the output level in the range of 150Hz to 700Hz. The purpose of these adjustments is to allow fine-tuning of the mid-bass and midrange response of the system to better integrate with varying room characteristics. The adjustment is accomplished by a change in value of a parallel damping resistor in each woofer circuit. No series loss is caused by these controls.

System Orientation – The two low-frequency drivers operate over different ranges, as described earlier. For proper imaging, it is necessary that the midrange woofer (LF2) be in the inboard position for the pair of systems. The proper setting of the system orientation jumper bars can configure a single DD66000 system as either a "left" or a "right" system. It is necessary that both bars be moved together. Improper sound will result from staggering the bars. The bars select which woofer receives the low and which woofer receives the midrange signals. One system should be set to "left" and positioned as the left speaker system. The other system should be set to "right" and positioned as the right speaker.

HF Level – This switch adjusts the attenuation applied to the 476Be by approximately 0.5dB over the range of 1000Hz to about 8000Hz. The action is accomplished by trimming the main attenuation resistors. No additional parts are inserted in the signal path (Fig. 13).

The batteries provide a voltage bias to each of the capacitor positions in the various networks. The biasing of the capacitors is done through a large value resistor (2.2 megohm) and thus draws no appreciable current. The expiration date printed on the battery generally coincides with the need to replace the batteries. Each capacitor position is actually made up of two capacitors connected in series. The battery voltage is applied to the center connection of the two capacitors. This produces a voltage potential between the two plates within the capacitor. When the two parts are taken as a whole, there is no DC voltage that appears across them, but individually they are each biased. The sonic result of the biasing yields an increase in detail, increased smoothness and considerably more natural decay of sounds within the music.

CONCLUSION

The Project Everest DD66000 system comprises many individual parts, each of which is constructed using the latest techniques and the best materials available. Everything possible has been done to design and produce a system that measures well, looks great and is built to last. But is this sufficient to make the DD66000 the best system it can possibly be? No. There are many factors involved in the design of a complicated system such as this. This is where JBL's long history of outstanding engineering, both sonic and visual, comes into play. Although we are firm believers in the science of sound, we are also practitioners of the art of music. The DD66000 quite simply provides the most musical experience of anything in our history.

SYSTEM SPECIFICATIONS

Recommended Amplifier Power:	500 Watts
Frequency Response (–6dB, Anechoic):	45Hz – 50kHz
Bass Response (–10dB, Anechoic):	32Hz
Impedance:	8 Ohms nominal, 5.5 ohms minimum at 85Hz, 3.5 ohms minimum at 40kHz
Sensitivity (2.83V @ 1m):	96dB
Crossover Frequencies:	150Hz, 700Hz, 20kHz
Exterior dimensions (W x H x D):	965mm x 1092mm x 464mm (38" x 43" x 18-1/4"), plus 13/16" (20mm) for feet
Weight:	137kg (300 lb)

PRO SOUND COMES HOME™

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