

NOTE

Development of Time Domain Subwoofer

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Abstract

In April, 2001 we launched our Time Domain speaker System for home use under the "ECLIPSE TD" brand, for the purpose of demonstrating our acoustic engineering ability, and to strengthen our brand image. In addition, our ECLIPSE TD 316SW Subwoofer with a built-in amplifier was introduced in June 2003. By actualizing Time-Domain theory, the high-speed 316SW Subwoofer holds the line against any conventional subwoofers that attach importance to power and volume. In this technical notes, we introduce the market trends of the 316SW and speakers for home use which are currently available in the market.

1

Introduction

In April, 2001 we began to market our Time Domain speaker System for home use as the ECLIPSE TD, for the purpose of demonstrating our acoustic engineering ability, and strengthening our brand image. In addition, our ECLIPSE TD "316SW" Subwoofer with a built-in amplifier was introduced in June of this year (2003). By actualizing Time Domain theory, the high-speed 316SW supercedes any conventional subwoofers that attach importance to power and volume. At the same time, our new "307" Speaker was released to the market. The "307" is a compact speaker that fits into the palm of your hand; it is also enhanced by actualizing Time Domain theory in its internal design, and is compatible for desk-top multi-channel use. In addition, 2.1 and 5.1 Channel sound can be enjoyed in combination with the 316SW. In the technical notes, we introduce the market trends of the "316SW" and speakers for home use that are currently available in the market.

2

Background of product creation

2.1 Market trends of home-use speakers

Although a declining trend continued until 1998, the high-fidelity speaker market has tended to expand moderately since 1999, due to home-theater demand. (As we can see in Fig.2 from the market scale data of AV amplifiers, the demand for home theater use is growing rapidly.)

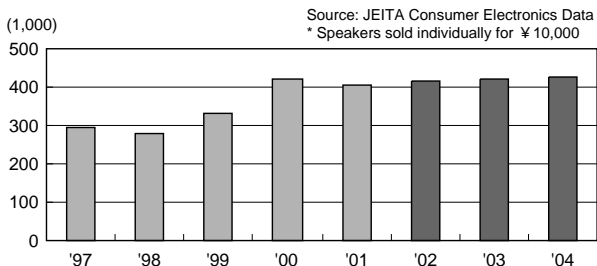


Fig.1 Domestic sales quantities of Hi-Fi speakers

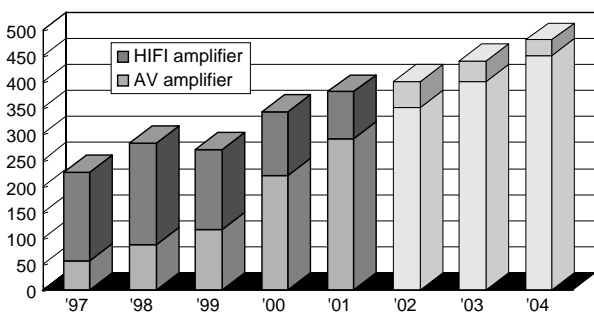


Fig.2 AV amplifier market size

In recent years, every audio manufacturer has marketed items that attach great importance to the nature of their internal "audio design," and has released unconventional products focused not only on audio designs.

Manufacturers are also concerned with outlet channels not limited by the definition of conventional audio stores, aiming at opening up new distribution channels, such as "interior shops" and "high-grade variety goods stores".



Fig.3 Audio designs of each company's products

Although there are many products with specialized designs, there are currently few systems with superlative sound quality.

2.2 Market demand

With our company's questionnaire of existing home-use audio (including a listening test evaluation), we observed:

- Although sound quality was acceptable, prices were high (especially in the general social class)
- Customers desire low-cost products with sound quality equivalent to that of current products.
- Customers want high-speed subwoofers.

2.3 Product concept

From these observations, we conceived of the "307 Series" as follows.

Small sized products with a reasonable price range, without losing the characteristic sound quality of Time Domain speakers;

To realize improvement in expanding the usefulness of a wide-range speaker system with a subwoofer;

To enter the interior market by improving design;

A system compatible with both home theater systems and commercial areas, etc.

Armed with the Time Domain theory, we sought to increase sales by supplying this new market with a product having "essence" and "freshness". The following will introduce to you the ECLIPSE TD, a subwoofer we first developed that was different from the shapes and characteristics of conventional subwoofers.

3

Problems with conventional subwoofers and ideas for improvement

3.1 Problems with conventional subwoofers

The following three big points can be considered as problems of conventional subwoofers for home use:

- The bass range is muddy (the sound is unclear).
- The response of the bass range sounds late (transient

response is poor; lack of sense of speed).

- The balance of the total speaker system is not good.

The muddy (unclear) sound is caused by large aperture speaker units attached directly to the speaker cabinet, and the mixing of sounds transmitted from the speaker unit and the cabinet.

The late response of the bass range is caused by large aperture speaker units (25cm or more) used to place importance on mass and decibels. Furthermore, to reduce F_0 , they are driven with a large output amplifier, and to make matters worse, made even heavier due to serious vibrations in the system. It is believed that the combination of the above reasons is the cause of the last problem in the balance of the total speaker system.

3.2 Ideas for improvement related to these problems

With regard for each problem mentioned in the preceding section, we can understand two key ideas for improvement with the Time Domain subwoofer system:

- Improvement in preventing unnecessary vibrations from being generated by the speaker;
- Improvement of the performance of large-aperture units.

The specific plan for improvement these two ideas is shown as follows:

Speaker

- A structure that does not transmit vibrations occurring in the speaker units to the speaker cabinet.

Speaker system

- Clearly define which speakers to combine and carefully consider balance in the selection of the aperture.

4

Basic structure

4.1 Structure examination

The internal structure of our Time Domain speaker ECLIPSE TD512 for home use is shown in Fig.4, and the internal structure of our recently developed subwoofer is shown in Fig.5.

The fundamental idea is the same as the ECLIPSE TD512, which is fitted with floating structure so that the speaker unit does not make direct contact with the speaker cabinet. The speaker unit has the structure attached with diffusion stays, and ground anchors ^(Note 1) that have enormous mass to cut off reactions ^(Note 2).

Furthermore, expensive aluminum die castings are used for the speaker cabinet material adopting irregular shape cylinders (Fig.6), which suppress resonance and standing waves as much as possible.

Moreover, the front of the speaker unit is equipped with a front load ^(Note 3), which has a structure with slits through which the sound is emitted, striving for a characteristic improvement in the range of bass sounds.

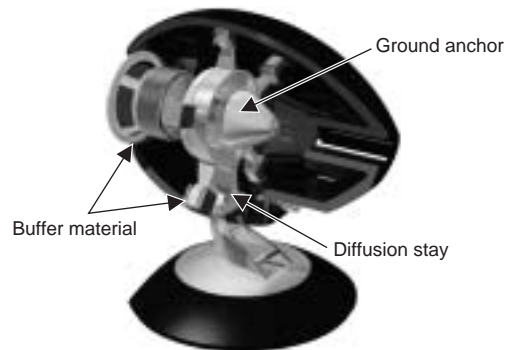


Fig.4 ECLIPSE TD512 internal structure

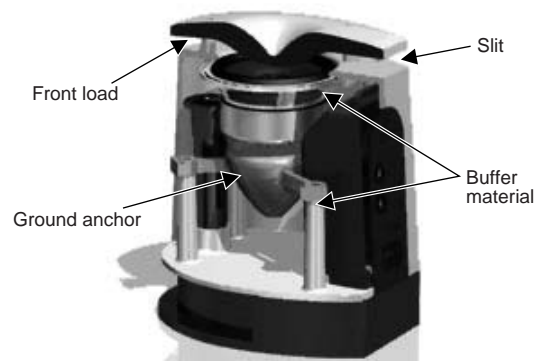


Fig.5 ECLIPSE TD316SW internal structure



Fig.6 Variant shapes of cylinder forms

4.2 Front load effect

By providing a front load, we were able to reduce F_0 from 103Hz to 98Hz. Consequently, the flat part of the bass range was able to expand, so that the flat zone was also able to expand. Moreover, the unnecessary resonance from the front load itself was also prevented by adopting aluminum die castings for the front load. As a result of actual listening auditions, much better effects have been gained than in the measurement data, and a

(Note 1) Original upholding structure for speaker unit

(Note 2) A structure in which the reaction of the vibration board are firmly stopped and absorbed by the mass and can acquire the ideal piston movement

(Note 3) Placed just in front of the speaker vibration board, this increases the efficiency of sound emission.

greater sense of speed could be felt by setting up a front load.

4.3 System configuration

The system configuration of the newly developed 316SW is shown in Fig.7.

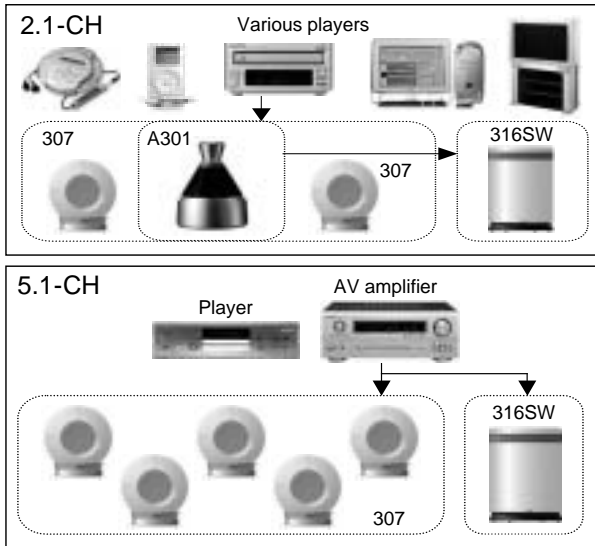
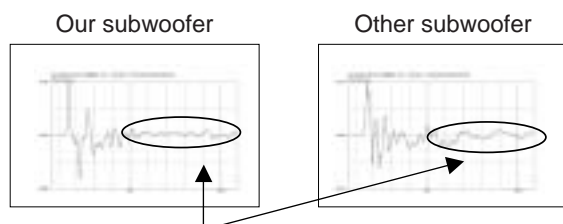


Fig.7 System structural diagram

Concerning the unit aperture, we came to attach great importance to the sense of speed and transient response, so we adopted a 16cm aperture, unlike the large aperture used by other manufacturers. Although our bass loudness is inferior if compared with the subwoofers of other manufacturers when assuming home theater use, ours won in speed and sound clarity. In actual market testing, we received very high evaluations of realistic presence from customers and reviewers who listening-tested 5.1 Channel sound. Comparison Comparative data of home-use subwoofers from other companies currently available in the market is shown in Fig.8 and Fig.9.

- Fig.8: Attenuation is faster than for that of other manufacturers
- Fig.9: Superior to other manufacturers in the prevention of unnecessary reflected waves



Clear difference in attenuation characteristics

Fig.8 Impulse response comparison with subwoofers of other manufacturers

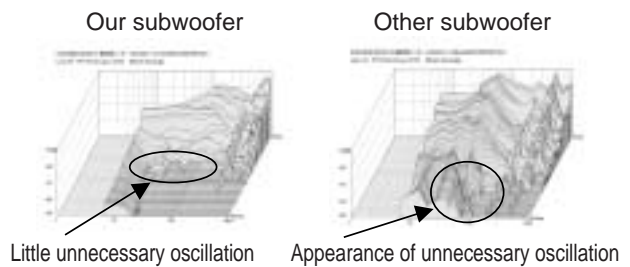


Fig.9 Comparison of cumulative spectra (Note 4)

5 Built-in amplifier summary

In order to exhibit the capacities of this speaker to the maximum extent, at the time of developing this subwoofer we elaborated on the built-in subwoofer amplifier. The summary is shown below.

5.1 Separation of the power supply and amplifier

It is common for subwoofers with built-in amplifiers in this class to include the power supply and amplifier in a single unit. However, unnecessary oscillations generated by the transformer itself are easily transmitted to the amplifier circuit. We did not want unnecessary oscillations riding on the audio signal to degrade the sound quality, so we utilized a structure that separates them. (Fig.10)

5.2 Separation of the amplifier and speaker cabinet

In the same vein as the above-mentioned item, back-pressure distortion vibrations emitted from the speaker unit that degrade audio quality are also transmitted to the amplifier circuit, so we arranged the amplifier as a separate component from the speaker cabinet. (Fig.10)

5.3 Simplification of the circuit

Based on time domain theory, we also simplified the internal circuitry to reproduce the sound data currently recorded as faithfully as possible, without affecting its original flavor. Moreover, there is just one input line, and functional controls were narrowed down to the minimum: volume, phase change, and cutoff only. With these settings, we were able to reproduce a very gentle sound.

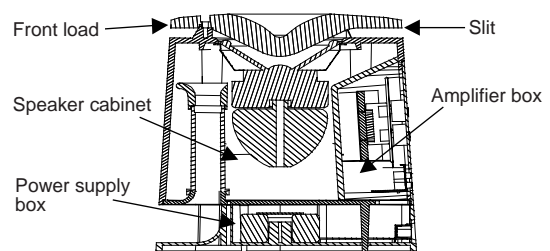


Fig.10 ECLIPSE TD316SW separate internal structure

(Note 4) The three dimensional graph displays the phase shift of the frequency components led by each impulse response that we searched for.

6 Product specification summary

- Speaker cabinet aperture: 16cm
- Rated output: 30W × 2
- Reproduction frequency bandwidth: 40Hz to 200Hz (-10dB)
- Crossover: 40Hz to 200Hz (continuously variable)
- Phase-change SW: 0/180 ° (slide type)
- AUTO POWER ON/OFF function
- Rate of higher harmonic wave distortion: 0.05% (100Hz, 1/2 rated output)
- Line input: 1 stereo system (analog)
- Line output: 1 stereo system (analog/through)
- Power consumption: 46W
- External dimensions: W236 × H354 × D301 (mm)
- Weight: 19kg (approximate)
- Accessory: AC power cord (2m)

Frequency characteristics of the speaker are shown in Fig.11, and impulse response in Fig.12. Structure is shown in Fig.5. The newly developed system is shown in Figs.13 and 14.

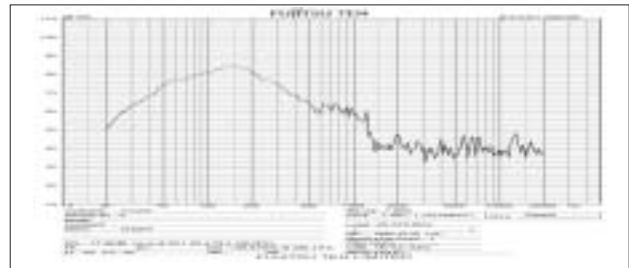


Fig.11 Frequency response of subwoofer

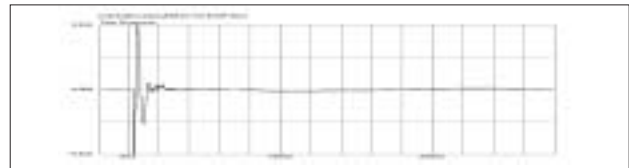


Fig.12 Impulse response of subwoofer

7 Conclusion

The sound of the commercial product marketed at this time has a sense of speed, clarity, and even achieves sound expression during playback. Especially when 5.1 Channel sound is played back, there is a sense of togetherness between listeners and the speakers, and we believe that with this total system, you will feel as if you are on the performing stage. This sound quality must impresses and move the hearts of many users, and we firmly believe that it will lead us to something completely new in the audio world.

In the future, of course we aim to continue to improve sound quality by improving the speakers and their structure. Finally, we wish to express our deepest gratitude to those people who cooperated in the development of this system, both within and outside our Company.



Fig.13 2.1 Channel system



Fig.14 5.1 Channel system

Profiles of Writers



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Entered the company in 1982. Since then, has engaged in development of in-car sound systems and from 2001 in home speaker development design. Currently in the Acoustic Engineering Department of Audio Business Division, Business Division Group.



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Entered the company in 1993. Since then, has engaged in development of in-car amps, and from 2002 in development of home TD amps. Currently in the Acoustic Engineering Department of Audio Business Division, Business Division Group.



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Entered the company in 1986. Since then, has engaged in car audio and music software development, and from 2001 in home speaker development. Currently in the Acoustic Engineering Department of Audio Business Division, Business Division Group.



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Entered the company in 1984. Until 1988, engaged in structural design of in-car stereos. Since then, has engaged in design development of in-car speakers, and this has continued to present. Currently the Manager of the Acoustic Engineering Department of Audio Business Division, Business Division Group.