Development of TD712z time domain speaker for home use

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Abstract

The April 2001 market launch of our "512" and "508PA" time domain speaker for home uses with the aim of enhancing our audio technology's appeal and brand image was followed by the June 2003 appearance of our "307 Series" in the popularization price range. These products have been steadily raising our market recognition. And aiming to further enhance our brand image, in November of 2004 we recently launched the "TD712z", FUJITSU TEN's premier luxury speaker. This paper provides an introduction to the key aspects of this newly marketed product.

1 Introduction

In April 2001 we launched the "512" and "508PA" time domain speaker for home uses onto the market with the purpose of enhancing our audio technology's appeal and our brand image. Then in June 2003 we brought out our "307 Series" in the popularization price range, since when our market recognition has gradually risen. And aiming to further enhance our brand image we recently launched the "TD712z" luxury speaker. This paper provides an introduction to the features of this newly marketed product.

2 Background to determination of the product

2.1 Market trend in home speakers

The market for Hi-Fi speakers can be broadly divided into the price range 600,000 yen/pair and under and the price range 1,000,000 yen/pair and over. The price for the newly developed product was set at 580,000 yen/pair because it is a model aimed at enhancing the brand image and also at expanding our sales volume.

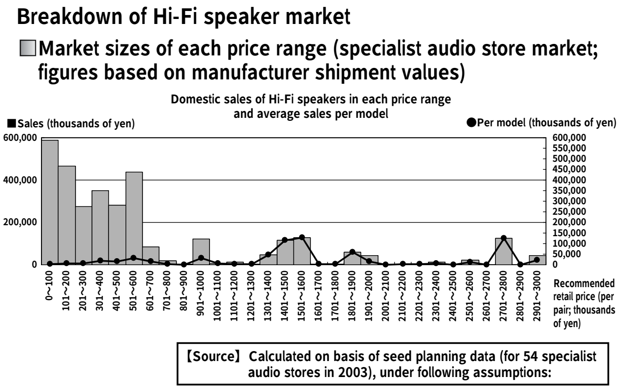

Fig.1 Hi-Fi speaker market size data

2.2 Survey of market needs

Before embarking on development of the "TD712z" we carried out a survey of the needs of users of our current "512" speaker. The results were:

①The audio quality was acceptable, but slightly higher bandwidth was desired. (In terms of spec, "20 kHz" high playback frequency bandwidth is necessary for a luxury model.)

②The stand is sold separately, so when the speaker is used without the stand it is susceptible to effects of the material or other properties of the surface it is placed on. (Integrated stand type is required, to protect against such effects from the surface.)

③When the speaker is mounted on the conventional "D2" stand in order to accommodate multichannel (5.1 channel) needs, the speaker impinges on the screen. (Dimensions must be determined that will give a height at which the speaker does not impinge on the screen. And the construction must allow adjustment of the speaker unit's angle to accommodate the height of the chair in which the listener sits, etc.) Below we describe the development concept for the TD712z that was determined in response to such needs and price requirements, together with the means for implementing such concept.

3 TD712z development concept and implementation means

The development concept for the TD712z was "Realize globally top-class acoustic space reproduction capability". The means for implementing the concept are shown in Fig. 2.

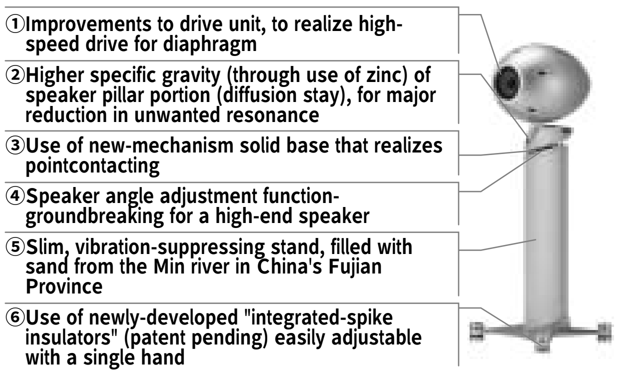

Fig.2 TD712z implementation means

The detailed discussion below focuses mainly on the following 3 of these implementation means: ① speaker unit, ② box construction, ③ integration of the stand.

3.1 Development of speaker unit

The goals of the development were to improve impulse response performance and eliminate resonance during pulse fall, while retaining the timbre of the current 512 speaker. The means to those goals were ① to reduce the vibration system mass, and ② to increase the magnetic force of the magnetic circuits. These are described in detail below.

3.1.1 Reduction of vibration system mass

The TD requires the following physical property of its diaphragm: ① low specific gravity; ② large internal loss; ③ high modulus of elasticity. But a survey revealed that extremely few materials satisfy those requirements. (Refer to Table 1.)

Table 1 Diaphragm physical property

Material	Specific gravity	Internal loss η	Modulus of elasticity Pa
Fiberglass	1.4	0.016	0.602
Magnesium alloy	1.77	0.004	0.410
Polypropylene	0.98	0.005	0.089
Aluminum	2.7	0.003	0.700

We conducted evaluation of diaphragms made of 2 likely materials among the above: magnesium alloy (which despite its high specific gravity can be made very thin, thus reducing total mass) and fiberglass, the material used in the "512". It was found that the magnesium alloy diaphragm gave better impulse response performance, but still has resonance in the 1 kHz and 8 kHz regions of its pulse fall cumulative spectrum (Note 1). Moreover, audio quality evaluation found that it gave the sound a "metally" feel peculiar to the magnesium alloy, presumably because of the low internal loss, which results in the material's own specific sound being retained in the audio sound. Since this characteristic conflicted with the TD concept of "not allowing any unwanted sounds", the currently used fiberglass diaphragm (in a different color) was adopted for the development.

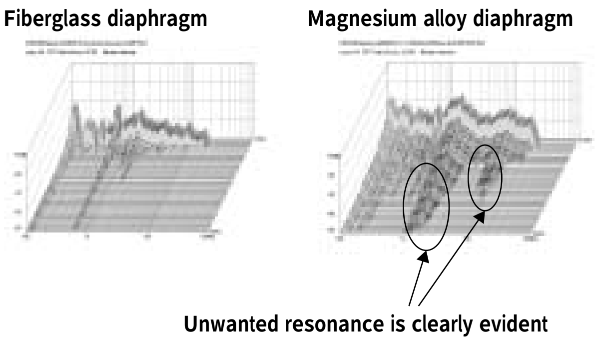

Fig.3 Comparison of pulse fall cumulative spectrum (Note 1)

Similarly we evaluated the mass, internal loss and modulus of elasticity of 2 materials for the voice coil: aluminum wire and the currently used copper wire. From the results for mass - and also from evaluation of the audio sound produced by each material - it was decided to adopt the aluminum wire, which provides a reduction of around 10% in the total mass of the voice coil.

3.1.2 Increase of magnetic circuits' magnetism

As a means of increasing the magnetic force, we studied increasing the flux density without change of the magnet's depth dimension and the diameter of the canceling cover. This means was selected because it was necessary to maintain the same box interior volume (as change in the volume would affect the low playback frequency bandwidth). As a result of the study we adopted a special magnet with outer diameter of 85 mm - the largest value that would allow it to fit inside the canceling cover - but with the inner diameter dimension unchanged, although it is usual to increase the inner diameter as well when the outer diameter is increased. By this means we were able to increase the flux density by around 20%.

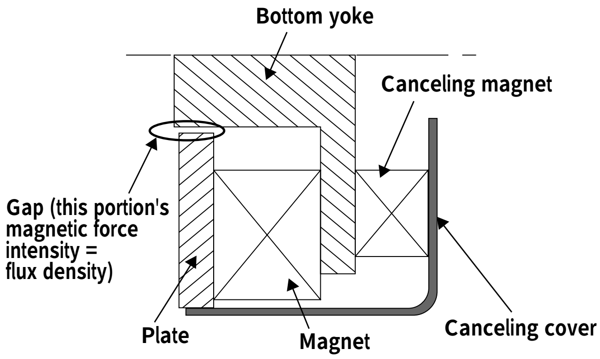

Fig.4 Magnetic circuit section

The reduced oscillation system mass and increased magnetic flux enabled a rise of around 10% in the impulse response performance. That in turn made possible an expansion of the high playback frequency bandwidth from 17 to 20 kHz, an improvement found necessary from experience with the "512". In this way the TD Series' high bandwidth is expanded via a unique approach, without addition of a tweeter.

Fig. 5 presents measurements of the impulse responses of the "TD712z" and the "512". It can be seen that the "TD712z" has higher response performance (greater response margin).

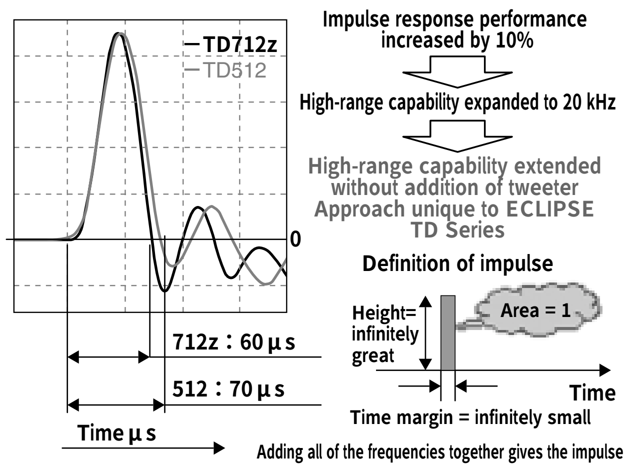

Fig.5 Comparison of impulse responses

Note 1: These graphs are 3-dimensional plotting of the variations over time of the frequency components derived from the respective impulse responses.

3.2 Speaker box construction

The box's basic construction is the same as that in the "512", but its arrangement and the members used for it were re-thought and optimized in the interest of reducing unwanted resonance. (Refer to Fig. 6.)

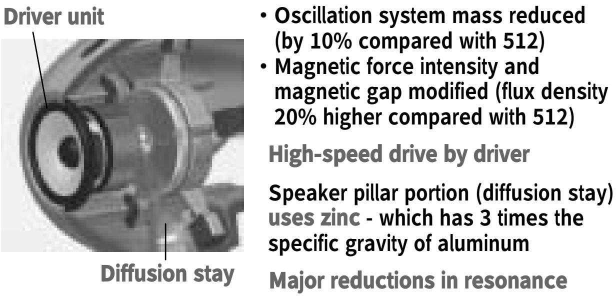

Fig.6 Construction of box in TD712z

3.2.1 Revision of stay material

Diecast aluminum is used for the stay in the "512". We searched for a material that could use the same dies and has superior physical properties. The material adopted as a result is diecast zinc, which has strength and internal loss superior to diecast aluminum. This new material permits major attenuation of unwanted resonance in the region of 10 kHz during pulse fall.

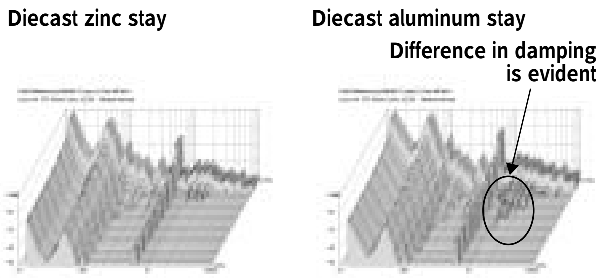

Fig.7 Pulse fall cumulative spectrum with different stay materials

3.2.2 Revision of sound absorbing material arrangement

In the "512", sound absorbing material is deployed at the magnetic circuit section of the speaker unit. But since there would be higher pressure exerted in the new product's box interior due to its increased max power input (30→35W) and larger sized magnetic circuits, etc., we examined more optimal arrangements of the material than the "512"'s. We found that arranging the sound absorbing material at both ends of the box interior produces a major reduction in unwanted resonance in the 600 Hz region during pulse fall. (Refer to Fig. 8.) In addition, listening tests showed that such arrangement yields clearer sound quality. Accordingly such new arrangement of the material was adopted.

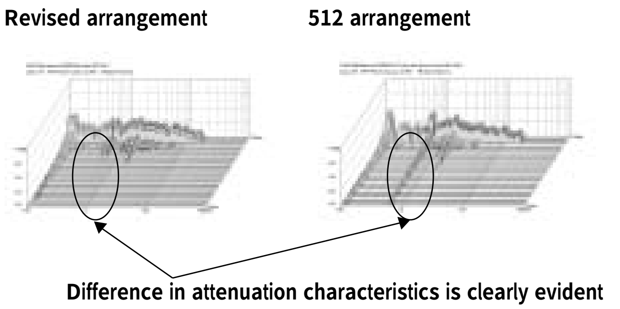

Fig.8 Pulse fall cumulative spectrum for old and new arrangements of the material

3.3 Integrated stand construction

The stand ("D1"/"D2") for the "512" is sold separately from the product itself, and the speaker is sometimes used without a stand. In such cases the sound is susceptible to the effects of the material or other properties of the surface that the speaker is placed on. Accordingly the TD712z is of a construction such that the stand is integrated with the speaker, so that the speaker can perform to its full capability at all times.

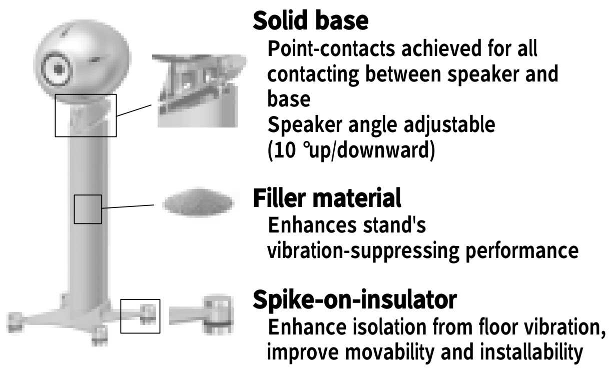

Fig.9 Integrated stand construction

3.3.1 New-mechanism solid base

Point-contacting in the form of spikes is used instead of surface contacting for the portions of the speaker box that contact with the stand. This is to facilitate downward escape of the vibration from the stay into the stand, and to make it difficult for vibration from below to be received upward through the contact portions. Further, construction allows the spikes' height and the box's angle to be varied - the latter by up to 10 ° in the upward direction. Such construction makes it difficult for vibration from the speakers to propagate to the box, etc., and permits adjustment to match the height of the listener's seat.

3.3.2 Deliberation of stand filler

It had been learned during development of stands for earlier models that sound quality and resonance during pulse fall vary with the type and quantity of the material used to fill the stand interior. But since the new product uses a thick, extruded aluminum material for its stand instead of the steel tubing traditionally used, we deliberated the type and quantity of the filler material afresh. The material types we examined were basically ones that can be obtained over the long term with consistent quality. We came up with four candidates: river sand, sea sand, Silica sand and iron sand. Sea sand however was quickly eliminated because it contains large amounts of salt that could have adverse effects on metal. The remaining 3 materials were considered by determining their pulse fall cumulative spectrum and by test listening. River sand was found to be the best material, in the quantity of 4 kg. (Refer to Figs. 10 and 11.) The factor making river sand the best filler seems to be that it is made up of grains of various sizes, which eliminates any resonance frequencies with the extruded aluminum material of the stand. An explanation of why 4 kg is the appropriate quantity for the river sand has not yet been found, but we will continue to pursue it in the interest of improving development efficiency and of acquiring know-how. Also, the river sand that was adopted is "custom made" for our company, having undergone a roasting process for the purpose of drying prior to delivery.

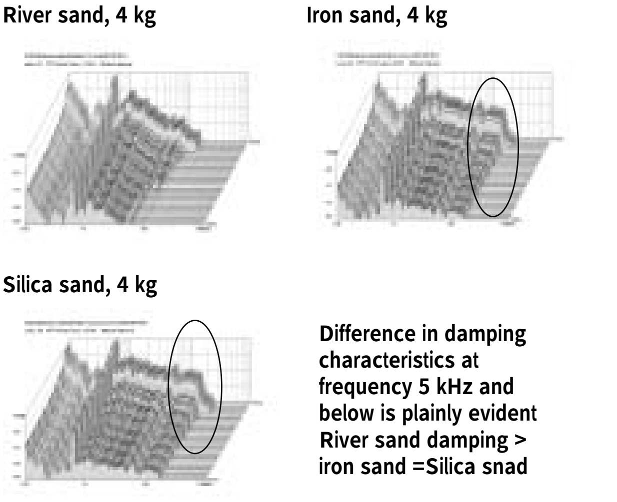

Fig.10 Pulse fall cumulative spectrum for different sand types

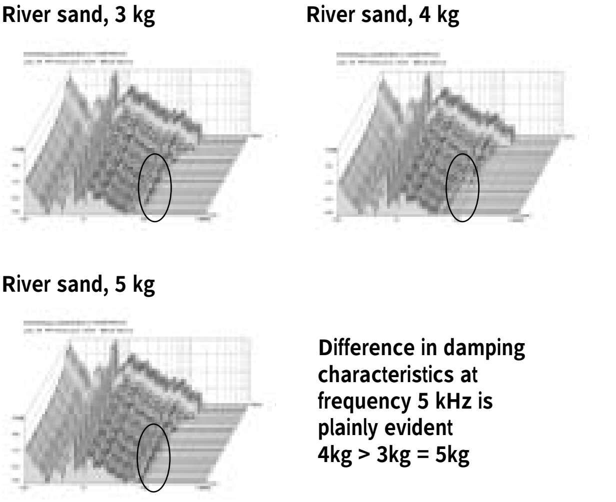

Fig.11 Pulse fall cumulative spectrum for different quantities of sand

3.3.3 Spike-on-insulator construction

The conventional "D2" and stands of other companies are of a type in which the stand's insulators are separate items from its spikes. We learned in the prototype stage that such type entails the difficult operation of aligning the positions of the spikes and insulators when the speaker is installed or moved. For the new product's stand therefore we developed a new "spike-on-insulator" construction that integrates the spike with the insulator. This is the first time such a construction has been employed by FUJITSU TEN. And the new spikes' heads are of a large size that can be easily turned with the fingers, instead of the traditional hexagon socket head. These features shorten the time needed to install the speaker, prevent scratching of floors and other surfaces when the speaker is moved, and greatly facilitate adjustment of the spike height. Many sales outlets and users who have actually used this have commented that the new construction greatly enhances convenience. (Refer to Fig. 12.)

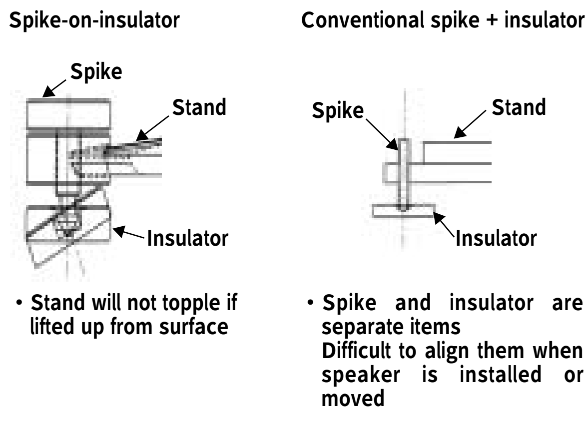

Fig.12 Comparison of insulator constructions

4 Outline of product specifications

- Speaker cabinet aperture: φ12 cm
- Rated input (maximum input): 35W (70W)
- Sound pressure frequency level: 83.5 dB/w・m
- Playback frequency bandwidth: 40 Hz to 20 kHz
- Impedance: 6Ω
- External dimensions: W347×D384×H988 (mm)
- Mass: 32kg (approximate)

The speaker's sound pressure frequency characteristics are shown in Fig. 13 and its impulse response in Fig. 14.

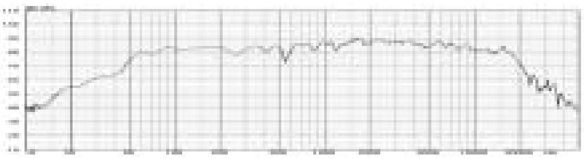

Fig.13 TD712z sound pressure frequency characteristics

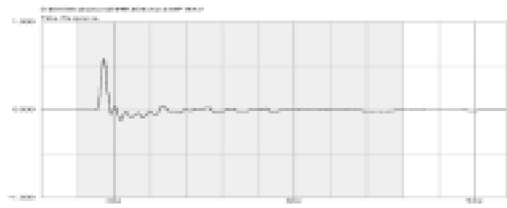

Fig.14 TD712Z impulse response characteristics

The appearance of the newly developed TD712z is shown in Fig. 15.

Fig.15 Appearance of TD712z

5 Conclusion

The newly developed speaker achieves a new level of perfection as a commercial product, while retaining the fine audio quality and aesthetics of the current " 512 " model. It has received high appraisals from dealers, critics and ordinary visitors who have seen and listened to it at previews and at the A&V Festa.

In the future we will be making structural and other improvements to the speaker with the aim of further heightening its audio quality, and also will be reflecting the know-how acquired through the present development in our car speakers.

Lastly we would like to express our sincere thanks to all concerned inside and outside of the company who gave us their assistance in the present development, particularly the many people we consulted often and in depth concerning the detailed shape of the pillar portion of the stand, for which a large-sized extruded aluminum molding was used. The die for such casting is large-size and the machines to form it exist only in small numbers across the country. Nevertheless the advice we received (on dimensions control, etc.) enabled us to achieve both vibration suppression and design quality for the pillar portion, and to incorporate it into the marketed product.

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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