

Development of Time Domain Speaker: TD712zMK2

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Abstract

FUJITSU TEN has been developing and launching speakers based on Time Domain theory since 2000. This speaker series is highly praised in the market all over the world for its novel design and accurate reproduction of input sounds.

Since the release of TD712z as a flagship model in 2004, we have recognized the market needs for higher capability of bass reproduction and easier installation, with expectations of developing and releasing a new model of the series.

Our new model 712zMK2 has extended the bass reproduction range to the lower-limit of 35Hz, which used to be 40Hz, by reviewing the speaker unit design and enlarging the enclosure capacity while retaining the 12cm-speaker units.

Also, this model has succeeded dramatically in improving the angle adjustment structure: supporting the bottom of the enclosure by three spikes and requiring only one pulling screw centrally placed. With these improvements, this model was released in February 2009 as a user-friendly flagship model with toolless and hand-adjustable structure.

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Introduction

Since its release in 2001, our home audio systems, ECLIPSE TD series, have been highly praised in world audio magazines and elsewhere. They are now widely used not only by audiophiles but also by worldwide top artists, being used regularly in the top studios throughout the world.

Specially our TD712zMK2, the successor of TD712z released in 2004 as a flagship model, has been much praised since its release in February 2009.

This paper explains the current status of FUJITSU TEN home audio products, and goes on to explain the development background, development concept and development results.

2 Current Status of ECLIPSE Home Audio Speakers**2.1 Concept Underlying Sound Creation**

The concept underlying ECLIPSE home audio speakers is to reproduce accurate sounds by reproducing accurate waveforms.

Most conventional speakers have been creating sounds with the aim of high-powered / wide range sounds by focusing on frequency response, emphasizing the ability to reproduce flat sound from low frequencies to high frequencies with minimum distortion.

On the other hand, at ECLIPSE, we have been creating accuracy- / nature-conscious sounds based on the time domain theory, which focuses on the accurate reproduction of the movement of air from sound generation to sound loss.

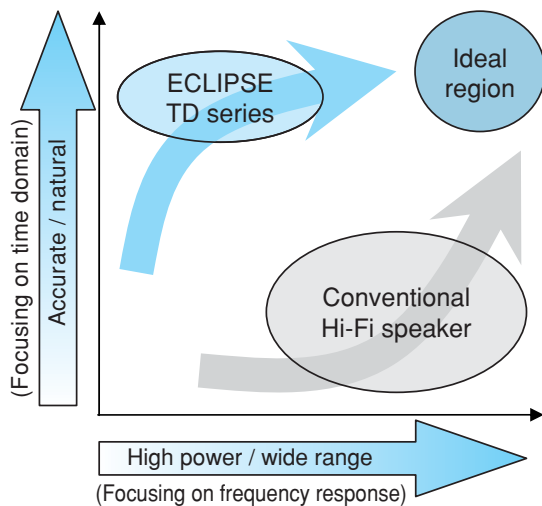


Fig.1 Concept Map in Sound Creation

2.2 Unique Technology Employed for ECLIPSE TD Series

One of the factors causing an adverse effect on the accurate reproduction of waveforms is "reverberation" of

a speaker. Here are three principal technologies that we have developed to minimize the unwanted vibrations that are the major factors in reverberation.

(1) Grand anchor

A conical metal object called a ground anchor is set in the back of the speaker unit, and its inertia mass suppresses the reaction of a speaker unit. This structure enables a cone to push air accurately.

(2) Floating structure

This adopted floating structure eliminates mechanical contact between the enclosure and the speaker unit, and suppresses the transmission of vibrations of the speaker unit to the enclosure. Therefore, the enclosure-specific vibrations are reduced and this leads to the minimization of the speaker-specific unwanted sound.

(3) Eggshell enclosure

The eggshell enclosure achieves the suppression of standing waves due to no parallel surface in the enclosure.

Besides, the shape makes the baffle surfaces round with no corners and leads to the suppression of the diffraction waves that are normally generated in the process of sound (spherical wave) expansion.

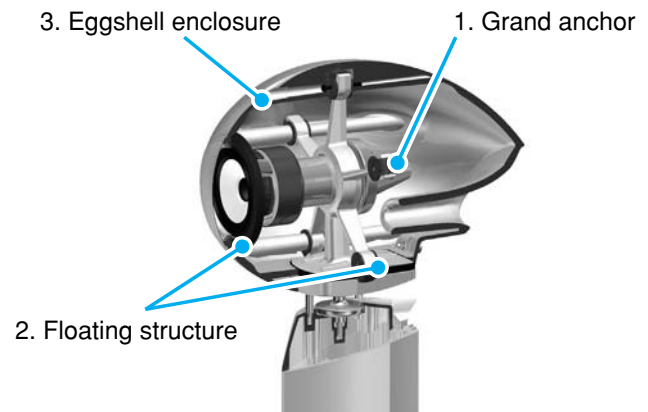


Fig.2 Internal Structure of TD712zMK2

2.3 Sound Characteristics of ECLIPSE TD Series

The sounds of ECLIPSE TD series which are pursuing the reproduction of the most accurate waveforms possible, have the following three major characteristics.

(1) Increased sound clarity

(Even minute sounds are heard without masking unwanted sound)

(2) Faster and tighter reproduction of sound

(The rising and falling of sound reproduction are both quick)

(3) Improved space reproduction

(The listeners are now less aware of the existence of speakers, which means that what they hear comes from their surrounding space)

3 Development Background

3.1 Evaluation / Task of Previous Model (TD712z)

The previous model aimed the ideal region based on the above-mentioned sound creation concept. However, we received feedback that the model has less power in bass than the conventional Hi-Fi speakers.

Also, we received many requests for a model with a simpler structure for setting to the appropriate listening points by adjusting the enclosure angle shown in Fig. 3: the previous model required tools for an adjustment at four points.

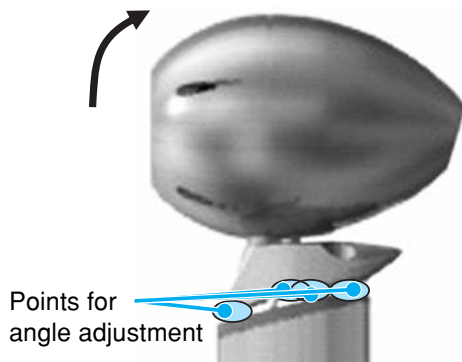


Fig.3 Angle Adjustment Function of TD712z

3.2 Development Concept

To solve the tasks mentioned above and to go close to the ideal region as a flagship model, we decided to change the model. The development concepts for the new model are as follows.

- (1) As a flagship model, to keep the level of or upgrade the level from the previous model in accuracy of waveforms, and to aim at wider range
- (2) To improve the installation workability by simplifying the angle adjustment

As for the design, the several models released since 2005 (TD510, TD508 II, TD307 II) are highly praised in design because of their organic enclosure forms. Thus, we decided to adopt the design in this model across the series at the time of model change.



Fig.4 TD Speaker Series Released Since 2005

4 Development of TD712zMK2

To achieve the concept mentioned in Section 3.2, we considered the following points to develop TD712zMK2.

1. Lowering limit of bass reproduction
2. Keeping or improving impulse response
3. Simplifying angle adjustment

Here are the details of this development.

4.1 Lowering Limit of Bass Reproduction

The previous model was developed aiming at the ideal region based on the above-mentioned sound creation concept. However, since the previous model had less power in bass than conventional Hi-Fi speakers, the new model was demanded to have a lower limit of bass reproduction.

Generally speaking, in order to lower the limit of bass reproduction, one method for making the lowest resonance frequency (f_0) lower is by adopting a larger-mass vibration system of a speaker unit.

However, as a trade-off problem, adopting the larger-mass vibration system will make the performances of transient responses worse and especially sound rising worse.

In the development of TD712zMK2, instead of adopting the larger-mass vibration system, we decided to take a measure to reduce stiffness (stiffness in cone's vibration). This requires the influence of back pressure inside a speaker box to the cone's vibration to be small. So, we adopted an approx. 1.5 times capacity (compared to the previous model) with design in mind so as to lower the limit of bass reproduction. With this enlarged enclosure capacity, the (design) constants of the speaker unit, such as f_0 , were obtained by simulating the bass reproduction with setting the target to approx. 5Hz lowered of bass reproduction limit. (Fig. 5)

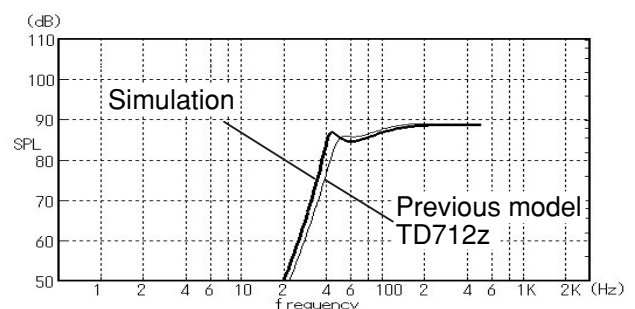


Fig.5 Simulation of Bass Reproduction

The TD712zMK2 developed as above enables the reproduction of richer and higher quality bass above the lower limit of 35Hz, which used to be 40Hz. The following figure (Fig. 6) shows the comparison of frequency responses, indicating our success to lower the limit of bass reproduction.

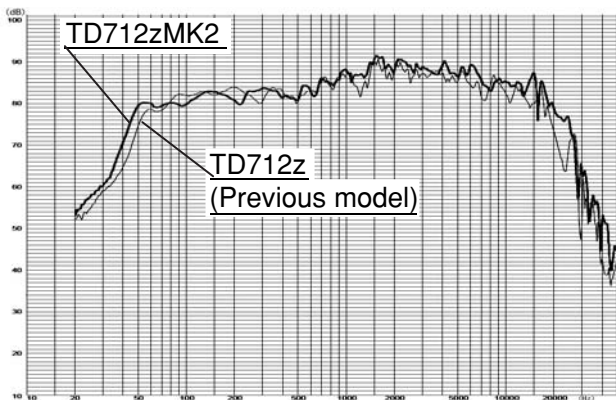


Fig.6 Comparison of Frequency Response

4.2 Improving Impulse Response

Time domain speakers are developed with focusing on the accurate reproduction of time waveforms of sounds, in other words, impulse response.

The points and the method for improving impulse response in the development of TD712zMK2 are as follows. (Table 1)

Table 1 Point and Method for Improving Impulse Response

Point	Method
Rising	Magnetic circuit enhancement
Falling	Reduction of unwanted resonance by enhancing internal loss of cone
Accuracy in waveform	Improvement of symmetry property of forward-and-backward amplitude in supporting system

4.2.1 Magnetic Circuit Enhancement

For the grand anchor of this development, we adopted the same inexpensive and easily-worked iron material as the conventional products. However, when the iron material is installed to the back side of the speaker unit directly as in Fig. 7, magnetic flux leakage occurs, which leads to the decrease of the cone's driving force and exerts a bad influence in the rising characteristics of impulse responses. In this development, we adopted the structure that minimizes the magnetic flux leakage by inserting a nonmagnetic spacer between a speaker unit and a grand anchor. Further, we took some other detailed measures such as setting the speaker unit and the grand anchor apart with an optimized distance, and adopting a nonmagnetic stainless-steel screw to fix the grand anchor. This development resulted in improvement of magnetic circuit efficiency; approx. 10% up of magnetic flux density compared to the conventional density.

$$(1.1T \rightarrow 1.25T)$$

Conventional model

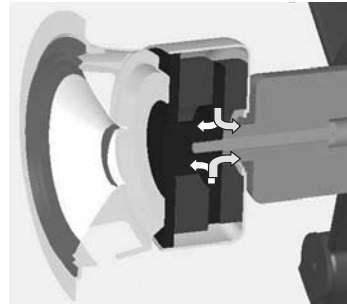


Fig.7 Conventional Magnetic Circuit / Grand Anchor Structure

TD712zMK2

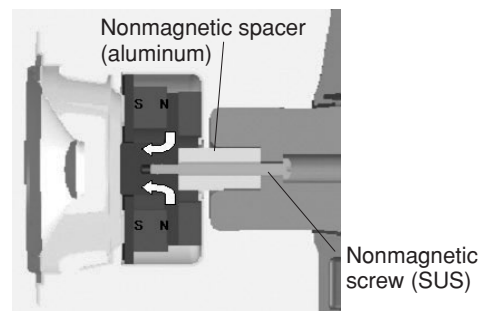


Fig.8 Developed Magnetic Circuit / Grand Anchor Structure

4.2.2 Reduction of Unwanted Resonance by Enhancing Internal Loss of Cone

The cone in the previous models comprised only one layer of fiberglass, however, in this development we affixed cotton: high internal loss material, to the rear of the fiberglass to make a dual structure (approx. 25 times of internal loss). Fig. 9 and Fig. 10 show respective impulse responses of these two cones.

With these figures, the dual layer cone is much superior in reducing the unwanted resonances.

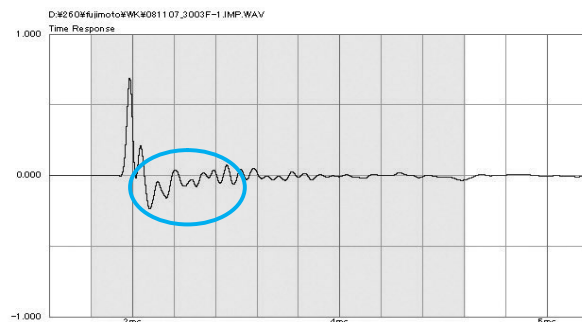


Fig.9 Impulse Response (cone: one layer of fiberglass)

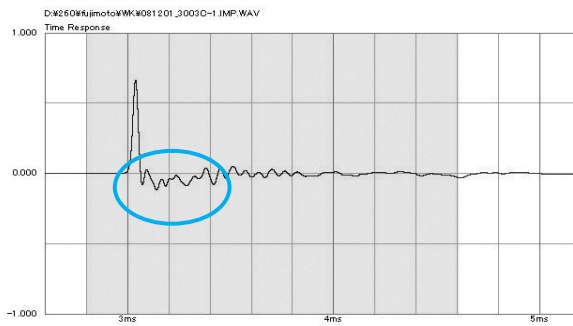


Fig.10 Impulse Response (cone: dual layer of fiberglass and cotton)

4.2.3 Improvement of Symmetry Property of Forward-and-backward Amplitude in Supporting System

To reproduce time waveforms of sounds accurately, the symmetry property of forward-and-backward amplitude to input signals in the supporting system of speaker cone must be improved.

As for the surround, conventional speakers use a general rolled surround, which has a tendency to move forward smoothly but backward jerkily.

In this development, we adopted a corrugated surround that is superior in amplitude linearity. Since the appropriate amplitude amount for the corrugated surround has to be ensured, we obtained the optimized shape of the surround by simulation to ensure the symmetry property of forward-and-backward amplitude even when there are significant power outputs. (Fig. 11)

As for the spider, we also obtained by simulation the corrugated shape superior in symmetry property of forward-and-backward amplitude. (Fig. 12) Fig. 13 is a simulation result. It shows that the forward amplitude (in gray) overlaps the backward amplitude (in black), and it indicates symmetry property is ensured.

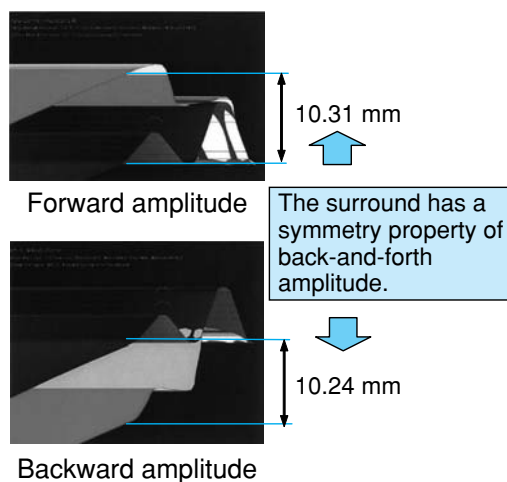


Fig.11 Simulation of Surround Amplitude

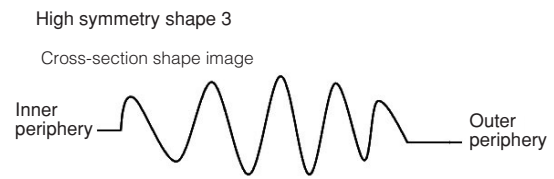
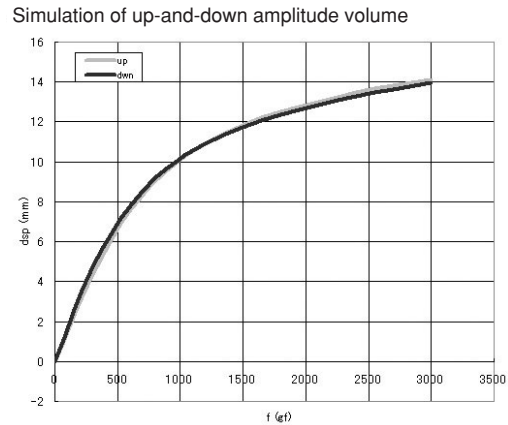


Fig.12 Cross-section Shape of Spider



Feature
This simulation is excellent in the symmetry property of up-and-down amplitude up to 14mm each range and the amplitude volume with 1kgf load or less.

Fig.13 Simulation of Spider Amplitude

As mentioned above, the optimized shapes for the surround and the spider were obtained by simulation. Making a test sample with these shapes, we verified the effect. Fig. 14 and Fig. 15 show the forward-and-backward amplitude characteristics of our conventional products and developed products. With these figures, the conventional products have gaps in amounts between forward and backward amplitude, and besides, have surround resonances up and down in a graph line depending on the frequency. By contrast, the developed products have the matched amounts in forward-and-backward amplitude characteristics and have the surround resonances modified smoothly in a line.

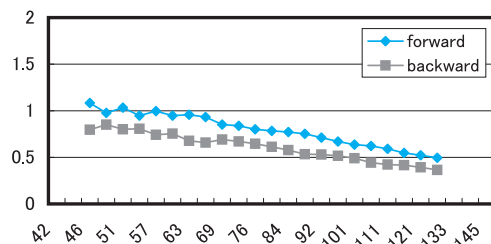


Fig.14 Amplitude Characteristics of Conventional Product

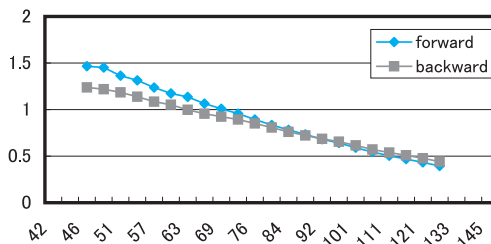


Fig.15 Amplitude Characteristics of Developed Product

4.3 Angle Adjustment Structure of Speaker

To realize the high-quality space reproduction, one of the TD speaker characteristics, speakers must be located correctly to face the listening point by adjusting their vertical angle (upward and downward) and horizontal direction (right and left). As for the direction, speakers can be positioned easily to face the listening point. However, as for the angle, speakers need to be adjustable in installation in accordance with the setting location or the circumstances of the room.

TD712z (previous model) was adjustable in the vertical angle in the range from 0° to +12°, enabling adjustment in angle in accordance with the height from the floor to the listening point. However, the structure required operations to adjust three pulling screws and one pushing screw (four screws in total) by extracting and inserting a tool (hex wrench) repeatedly. This complicated angle adjustment had to be simplified. (Fig. 16)

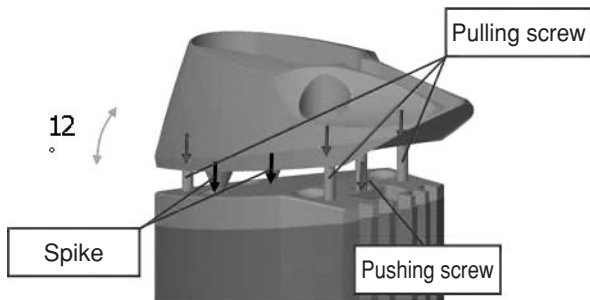


Fig.16 Angle Adjustment Structure of TD712z (Previous model)

So, in the development of TD712zMK2, we introduced the structure which sets three spikes above a post so that the speaker box can be fixed by one pulling screw on these spikes. The speaker is fixed on the spikes with the pulling screw that is screwed into the upper side of the post and that is hooked at the screw head to the ditch of the enclosure's bottom. Besides, since it is possible to grab the outer part of the $\phi 60\text{mm}$ disc shape at the periphery of the pulling screw axis, tools are not necessary for screwing the speaker. With this structure, we succeeded in reducing the required time for angle adjustment to approx. 10s, which used to take couple of minutes for one screw. (Fig. 17)



Fig.17 Angle Adjustment Structure of TD712zMK2

4.4 Specifications

TD712zMK2's appearance (Fig. 18) and major specifications are as follows.

Table 2 Specifications

	TD712z (Previous model)		TD712zMK2	
	Regular	Short	Regular	Short
Speaker unit (cm)	$\phi 12$		$\phi 12$	
Impedance (Ω)	6		6	
Frequency Response (Hz)	40 to 20k		35 to 26k	
Maximum dimensions (mm)	W347 × H988 × D384	W347 × H600 × D384	W347 × H1000 × D431	W347 × H611 × D431
Weight (kg)	25	18	25	18



TD712zMK2 (Regular)



TD712zMK2 (Short)

Fig.18 Appearance

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Conclusion

This paper has described the development for TD712zMK2, the newly remodeled flagship model of this series, while mentioning our product technology based on Time Domain theory.

Since the first release in 2001 of ECLIPSE home audios, we have developed and released various models based on a unified concept of underlying sound creation. This year is the ninth year since the first release. Users such as musicians and recording engineers, who sympathize with our wish to carry artist's sensibility by reproducing accurate sounds, are increasing yearly. This model is a flagship model. We keep trying to develop superior products by improving our technology.

We sincerely appreciate the efforts of everyone concerned inside and outside the company for this development.

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