

Development of Time Domain Speaker: TD307

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Abstract

FUJITSU TEN has been developing and launching the 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 original sounds. Since the release of TD307 in 2003, a compact Time Domain speaker as an entry model, we have recognized the market needs for higher capability of bass reproduction and more flexibility of installation, with expectations of developing and releasing a new model of the series.

This succeeding model TD307 has enlarged enclosure capacity, with inheriting the 6.5cm-speaker units, and expanded the bass reproduction range to the lower-limit of 100Hz, which used to be 120Hz. Also, this model has succeeded dramatically in improving the installation structure (angle adjustment) with the neck angle range from -25° to $+90^{\circ}$, which used to be $\pm 30^{\circ}$. With these improvements, this model was released in April 2007 as the products satisfying the market needs. Since the release, it has been praised in the market, and won various awards in audio magazines.

1

Introduction

Since its release in April 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, while being used regularly in the top studios throughout the world.

This year, in April 2007, "TD307" was released, with remodeled "TD307", being the entry model in the series. This new "TD307" has been praised since its release, just as the previous model: TD307, released in June 2003, and other "ECLIPSE TD" series that have won various awards in world audio magazines and others.

This paper explains Time Domain theory, which is the backbone of our ECLIPSE TD audio systems, while giving a brief overview of our product technology to turn this theory into reality. Then it goes on to explain the development background, improved points for remodeling, and a reputation in the industry.

2

Current Status of ECLIPSE TD Series

2.1 Product Line-up of the TD Series

The product line-up of all the ECLIPSE TD series so far has consisted of four full-range speakers (TD712z, TD510, TD508, TD307) and two subwoofers (TD725sw, TD316sw). All these models have been developed based on the same concept in sound creation.



TD307 (Previous model) TD307

Fig.1 Photos of Products

2.2 The Concept Underlying ECLIPSE TD Series

Most conventional speakers have focused on "frequency response", a measurement of the ability to reproduce flat sound from low frequencies to high frequencies with minimum distortion. On the other hand, our ECLIPSE TD series is based on Time Domain theory, which focuses on the accurate reproduction of the "movement of air by the axis of time".

In the past, there were some theories and products that paid attention to time, such as adjusting the sound reaching time from each speaker unit in a multi-way speaker system. However, Time Domain theory pays more serious attention to time, and considers that the accurate reproduction of input sound waveforms within time domain is ideal for sound reproduction. Then, in

order to verify the accuracy of waveforms, impulse response is used as an indicator. Impulse includes all the frequency elements; therefore, if impulse can be reproduced accurately, any sound waveforms can be reproduced.

Impulse response ← Impulse input

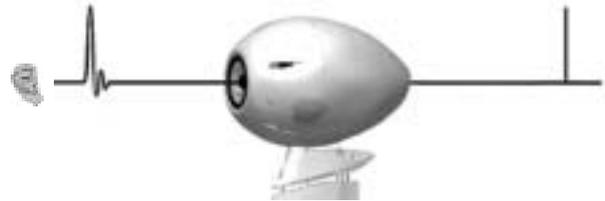


Fig.2 Impulse Response

2.3 Unique Technology employed for ECLIPSE TD Series

One of major factors that give an adverse effect on the accurate reproduction of waveforms is "reverberation" of speaker. There are three main technologies that we have employed to minimize: vibration, reflection, and resonance, which are major factors of reverberation. (Fig.3)

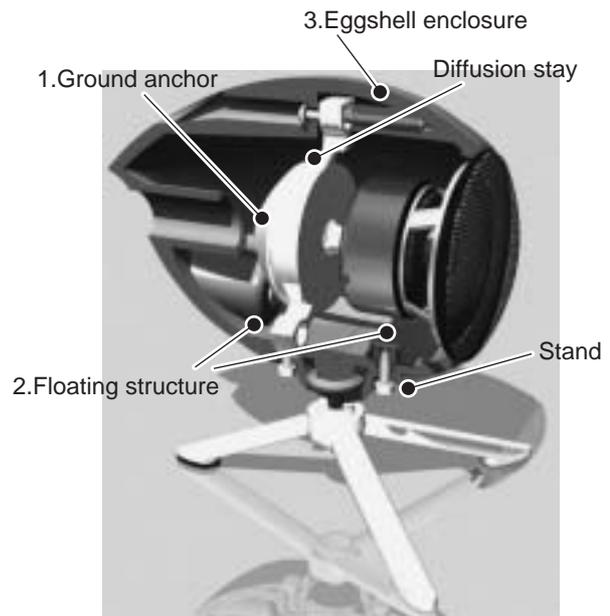


Fig.3 Internal Structure of TD307(Previous Model)

(1) Grand Anchor

Suppressing the reaction of speaker unit by the inertia mass of the ground anchor leads that waveforms rise without interferences, and that vibrations by the reaction (cause of undesirable sound generated) are suppressed.

(2) Floating Structure

Furthermore, separating a speaker unit from the enclosure prevents the transmission of vibrations generated by the speaker unit to the enclosures and leads to minimize undesired sound generated.

(3) Eggshell Enclosure

Both the standing waves (resonance) generated in the interior of enclosure and the diffracted effect (undesired reflection) caused by a round baffle, are suppressed by the eggshell enclosure.

2.4 Sound Characteristics of ECLIPSE TD Series

ECLIPSE TD Series, pursuing the reproduction of the most accurate waveforms possible, shows the following three major sound characteristics.

(1) Increased sound clarity

(Even minute sounds are heard without masking by unwanted sound)

(2) Faster and tighter reproduction of sound

(The rising and falling of sound reproduction are quick)

(3) Improved space reproduction

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

TD307 (previous model): the entry model of the ECLIPSE TD series, inheriting the above-mentioned series characteristics, has been praised highly overseas as well, for example, receiving a "FIVE STAR" rating in "What Hi-Fi?", an authoritative Hi-Fi magazine of U.K. and "Editors Choice 2005" in "Macworld" (Fig.4), a magazine for Mac (a famous music-productive PC by creators). Moreover, the series has gained great popularity among top artists and has been introduced into top studios. For example, John Williams, the classic guitarist, now uses ECLIPSE TD series regularly as the public address system for his concert.



Fig.4 TD307PA (Speaker & Amplifier Package)
Awarded "Editor's Choice" of "Macworld" Magazine

3 Development Background

3.1 Requests for Improvement on the Previous Model

While the TD307 (previous model) was praised, we received requests for improvement from users.

The following two requests were the most remarkable.

(1) Need more bass.

(2) Want to install on a wall as well as on a ceiling

It would be difficult to meet these requests by improvement of the driver unit or the partial modification of mechanism only. Thus, we decided that the whole parts should be renewed.

3.2 Tasks to Meet the Requests for Improvement

Here are the following tasks for improving speakers to meet the requests, (1) and (2) in Section 3.1 with keeping the advantage of the previous models.

(1) How to gain the feeling of more bass while minimizing the size of enclosure increased in accordance with the driver unit.

(2) How to make it possible that the speaker can be installed on a wall or a ceiling by itself while matching with the atmosphere.

As for task (1): gaining the feeling of more bass, the enclosure capacity must be enlarged to some extent in order to ease the driver unit movement for bass range. But, if the capacity is enlarged too much, that loses the advantage of this model, easy installation.

As for task (2), if making the speaker capable of various ways of installation as an easy solution, that may lead to lose the design advantage of this model because of its complicated appearance.

So, we have discussed the permissible enclosure size and the mechanism capable of installation to a wall, aiming at keeping the excellent design as well.

A conceivable mechanism to clear task (2) is to enlarge the adjustable range by changing the angle adjustment part (with bold pointer) in Fig.5 below. However, the bigger the adjuster part becomes, the weirder the speaker becomes in appearance. We had eyes on this point to be worked out in order to solve the task (1) and (2) at the same time.

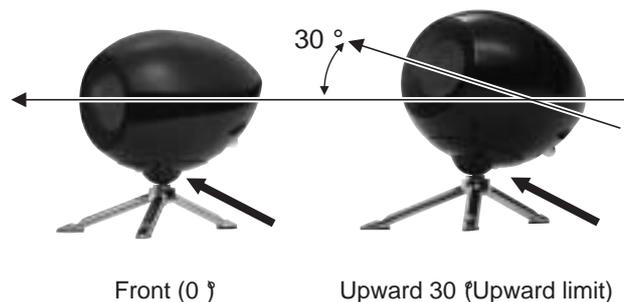


Fig.5 Limit of Angle Adjustment

4 Development of TD307

We have picked up the following points in the development of TD307 to solve the tasks mentioned in Section 3.1.

1. Lowering the limit of bass reproduction
2. Enlarging the range of angle adjustment
3. Improving installation capability

Here are the details of our product development.

4.1 Lowering the Limit of Bass Reproduction

Generally speaking, in order to lower the limit of bass reproduction, speakers are designed by using the following measures.

(1) Making the lowest resonance frequency (f_0) of the speaker unit lower.

(2) Enlarging the enclosure capacity.

(3) Intensifying the bass reflex resonance effects.

However, there are trade-off problems as follows.

(1) The bigger mass of vibration system makes the performance of the transient response worse.

(2) The larger outer dimensions lower the usability (capability of installation).

(3) The more the bass reflex resonance effects are intensified, the lower the performance of the transient response becomes because of the resonance in duct.

TD307 (previous model), emphasized on the compactness and lightweight for convenience in use (capability of installation) as above-mentioned, has been popular for the handiness. On the other hand, there were requests for more rich bass reproduction.

So, TD307 has been revised in outer dimensions in consideration of the design as well, with enlarging the capacity to approx. 1.5 times that (of the TD 307), so as to lower the limit of the bass reproduction.

The unit f_0 , enclosure capacity, and bass reflex duct dimensions were calculated by simulations. (Fig.6)

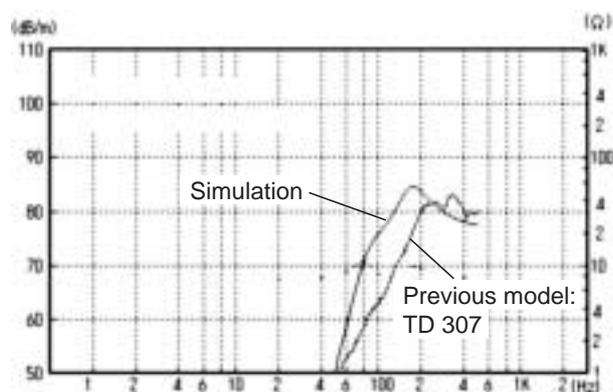


Fig.6 Simulation of Bass Reproduction

The speaker unit was improved in the support parts mainly, so as to enable it to respond to the large-amplitude in the bass range without stresses. This made the lowest resonance frequency lower with the amount of approx. 80Hz.

With those improvements above, the newly designed TD307 succeeded in lowering its limit of bass reproduction to 100Hz, which used to be 120Hz in the TD307 (previous model) and that brought the deeper and higher-quality bass. The following figure (Fig. 7) is the comparison of frequency response, showing the bass reproduction

range enlarged along the aim.

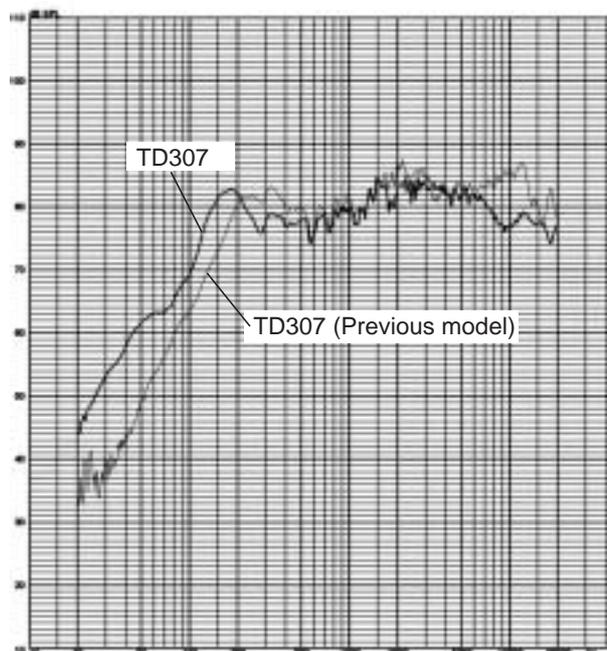


Fig.7 Comparison of Frequency Response

4.2 Function of the Speaker Angle Adjustment

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 are needed to be adjustable in installation in accordance with the setting location or the circumstances of the room.

TD307 (previous model) was adjustable in the vertical angle of the range from -30° to $+30^\circ$, enabling adjustment in angle in accordance with the height from the floor to the listening point.

Further, as for the installation to a wall, the angle was adjustable to the range up to 30° from the wall, and applicable to the listening position against the wall, such as in the case of satellite speakers.

The fact is, the bigger the speaker angle adjustment range becomes, the wider the choices of listening point becomes. But it requires enlarging the moving area of the adjustment part by making the dimensions of the angle adjustment mechanism bigger, resulting in the whole size of the speaker increased, which strays from the product concept.

So, we have developed a new compact angle adjustment mechanism for TD307, which enables the speaker to face wherever the listening point is.

The angle adjustment part of TD307 consists of stay, joint bolt, bottom cover, neck, and fixing bolt as in Fig.8.

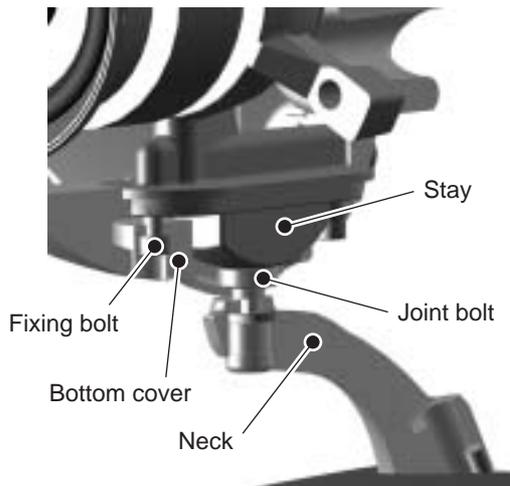


Fig.8 Angle Adjustment Mechanism

First, clip the end of the joint bolt fixed to neck with bottom cover and stay, then, tighten the fixing bolt. When adjusting the angle, loose the fixing bolt, tilt the speaker to the adequate angle, and then retighten the fixing bolt.

With the new mechanism, adjustable angle range itself is from -25° to $+30^{\circ}$, smaller than that of TD307 (previous model). However, changing the neck assembly direction enables the adjustable range from $+35^{\circ}$ to $+90^{\circ}$, resulting in wider choices of the listening position.

The figure below shows the angle adjustment range by the neck assembly direction in TD307 (Fig. 9)

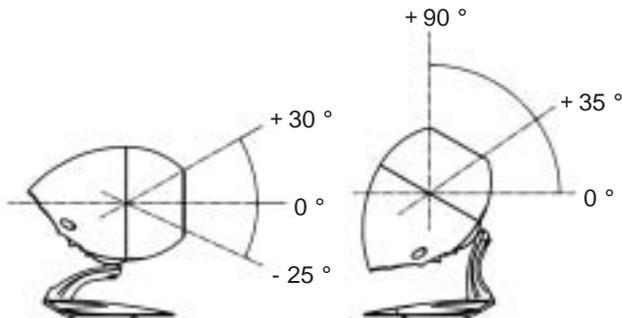


Fig.9 Shift in Angle Adjustment Range by the Assembly Direction of Neck

Also, the enlarged angle adjustment range made more options in installation available as shown in following figures. (Fig.10, 11)

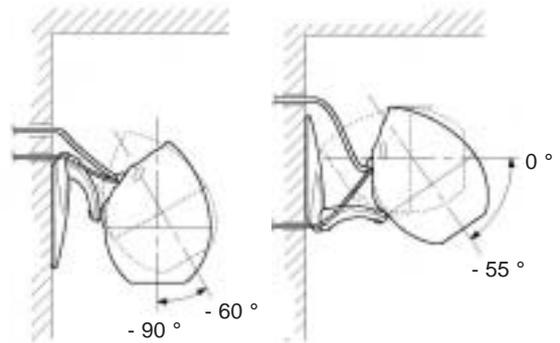


Fig.10 Variations of Installation on a Wall

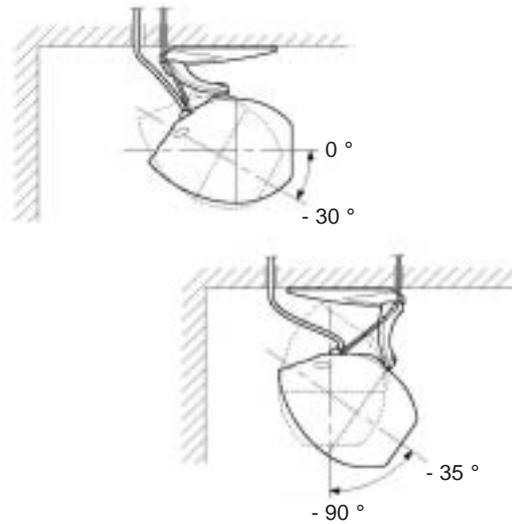


Fig.11 Variations of Installation on a Ceiling

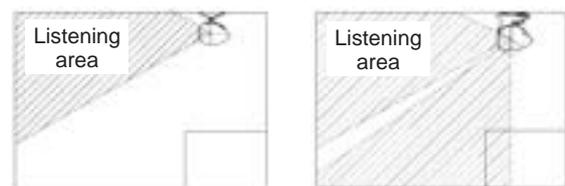
The figures below show comparisons of listening area of TD307 (previous model) and TD307, in the case of setting the listening point on the axis of the speaker unit. (Fig.12, 13, 14)



TD307 (Previous model)

TD307

Fig.12 Comparison of Listening Area in Case of Setting on a Desk



TD307 (Previous model)

TD307

Fig.13 Comparison of Listening Area in Case of Installation on a Ceiling

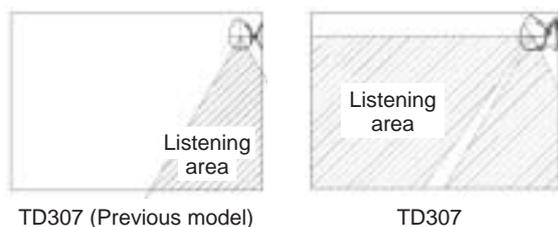


Fig.14 Comparison of Listening Area in Case of Installation on a Wall

4.3 Installation Mechanism

TD307 has holes for installation to a ceiling or a wall, as well as TD307 (previous model). TD307 (previous model) has installation holes on the base part, on the ends of tripod legs. In this structure, installation required great care in making holes, as it was impossible to adjust hole positions once they were made. TD307 has been improved greatly in this installation difficulty, by changing the base part to pressed steel sheet with oval holes. The following figures show the difference of installation holes.

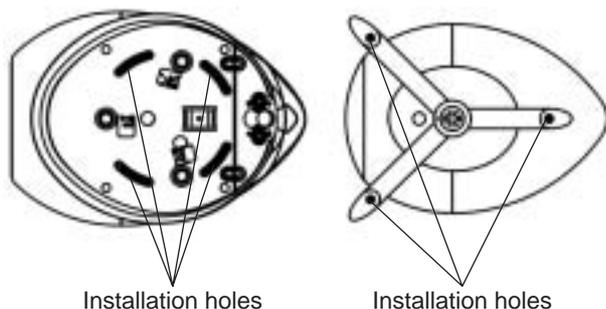


Fig.15 Installation Holes of TD307 and TD307(Previous Model)

4.4 Development Result

The development results in TD307 are as follows.

1. The bass reproduction limit lowered
120Hz 100Hz
2. The angle adjustment range enlarged
 $\pm 30^\circ$ -25° to 90°
3. More flexibility of installation
Horizontally fixed Adjustable

4.5 Main Specifications

TD307's appearance (Fig.16) and main specifications are as follows.

	TD307 (Previous model)	TD307II
Speaker unit	6.5cm	6.5cm
Impedance	8	8
Frequency Response	120Hz to 20kHz	100Hz to 25kHz
Maximum dimensions	W120 x H162 x D160 (mm)	W130 x H195 x D176 (mm)
Weight	1.2kg	1.5kg



Fig.16 Appearance of TD307 (Standard)



Fig.17 Appearance of TD307 (with D5, Exclusive Speaker Stand)

5

Market Evaluation

The TD307 developed as described so far, released in April 2007, has earned high recognition for its capability to reproduce high quality sound beyond the imagination for this size, and has been granted awards in audio magazines.

5.1 Reputation in Domestic and Overseas Audio Magazines

As of September 2007, this new model has been granted the following awards in domestic and overseas audio magazines:

1. "What Hi-Fi?" Magazine (United Kingdom) Rated as five star (August 2007)

Abstract of the comment

Eclipse delivers sound so quick and natural that you feel like you're in the studio with the musicians.

2. Ongen Publishing Co., Ltd. (Japan) Visual Grand-Prix 2007 Summer

- Silver Award
- Home Theater Award



Fig.18 TD307TH (Theater Package)

5.2 Reputation at Design Award

TD307PA received "the Good Design Award 2007" which was announced on Oct 1st 2007.



Fig.19 TD307PA (Speaker & Amplifier Package)

6

Conclusion

This paper has described the development for the TD307, newly remodeled entry model of this series, while mentioning our product technology based on Time Domain theory.

Audio systems are the products that reflect individual tastes, since people, as individuals, possess diverse preferences in sound. In other words, the accuracy of sound reproduction based on Time Domain theory does not necessarily mean that it would meet the needs of all individuals. Traditional audio systems, with a focus on frequency response, seem to have been the products which were favorable for the people who prefer audio-like dynamic feeling based on frequency response and power. On the other hand, the products based on Time Domain theory have been created to achieve a natural audio quality. This natural audio quality, however, may give traditional audio fans an impression that the sound is lacking a punch. In turn, however, it offers many other things, such as comfort, truly natural tones of musical instruments, a clear and crisp sound as a result of speedy "stop and start" that are considered as important by musicians, while also revealing the level of techniques employed during the performance exhaustively.

This means that the listeners can experience skills of worldwide top-class musicians at home. Thus, we have moved our development to be some help for children who want to be a musician in the future and want to improve their level of their musical skills, while some music enthusiasts who love to listen to the music. The development of this entry model TD307 provides the opportunity for more people to have experience in natural sound. From this time on, our aim is to apply this technology not only for home use but also for in-car use, while keeping in mind to develop our own original product that may lead us to earn another worldwide recognition.

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"ECLIPSE" FUJITSU TEN LIMITED

Profiles of Writers



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Entered the company in 1986. Since then, engaged in the development of mechanisms for car audio systems, the development of music source, and has been in charge of the development of speakers for home-use since 2001. Currently belonging to the Acoustic Engineering Department, Audio Business Division, CI Group.



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