

Development of new DVD Deck: DV-04

Yutaka Matsunami

Kouichi Ogawa

Hideaki Terada

Yoshikazu Fujita



Abstract

In recent years, the DVD market has been expanding in parallel with the growth of multimedia products, and it is expected that DVD will be the most important products among all disc media available from this time onwards. The same situation can also be seen in the automotive electronics market, where popularity of navigation system is under way in earnest. In other words, the demand for car-navigation systems is on the increase rapidly, as a result of the market trend that almost all high-end vehicles now come with a navigation system as standard. However, as the word, "Digital Versatile Disc", suggests, the media can be used for various purposes, unlike other audio media, such as CD and MD. This paper describes the development of our new DVD deck, DV-04, which is compatible with these various application software available on the market.

1 Introduction

Since its first introduction as a digital image media on the market in 1996, DVD began spreading, and today, it has completely taken over the job once videotape was responsible for. Fujitsu Ten developed a DVD-ROM deck for navigation system in April 2000, and the sale has been increased in parallel with expansion of the navigation system market and popularity of DVD-Video. In 2002, Fujitsu Ten developed DV-01NV, a DVD-ROM deck with DVD-Video capability; then in 2004, released DV-03, a DVD-Video deck with capability of 4X variable-speed recording. However, the DVD market is highly competitive, which requires strictly meeting the needs of the market in terms of function, performance, as well as cost. This time, we would like to introduce our new DVD deck, DV-04, which we regard as the culmination of what we have achieved in the DVD deck technologies for all these years.

2 Development Objectives

Unlike CD and MD, each of which is a complete audio medium that consists of a single format, DVD is required to be able to support various kinds of applications. (Refer to Fig. 1)

The major characteristics of DVD that differs from other audio equipments are as follows:

- DVD is a format that attracts people for its versatility; therefore, it is necessary to be capable of supporting new media, such as compressed audio.
- DVD has a function as data storage, and it is required to be capable of high-speed access and playback.

- DVD is capable of interactive operation; thus, the functions to improve operability have to be equipped.
- DVD has a capability of 2ch audio output; but it also has a capability of Multi Channel Audio and Video output.
- Aesthetic quality is required for DVD, since it is often installed in high-end vehicles that come with a display screen.

Below shows the objectives in developing new DVD (DV-04), which was set forth in order to be capable of a wide range of applications required in the market. They were selected as a result of our investigation research, which was based on 1) the required specification from our seven major customers, and 2) the benchmark evaluations conducted by eight companies.

① Capability of new media

- DVD Audio that is required for luxury-model cars
- DVD-Video recording discs for digital broadcasting

② High-speed recording

- For CD: x16 variable-speed
- For DVD: x5 variable speed

③ Capability to be vertically mounted

- In order to extend the possibility to be mounted in more places available for in-vehicle equipments

④ Lower-audible-noise DVD

- Loading noise
 - PU Slide noise
 - Rotation noise
- All 6dB down

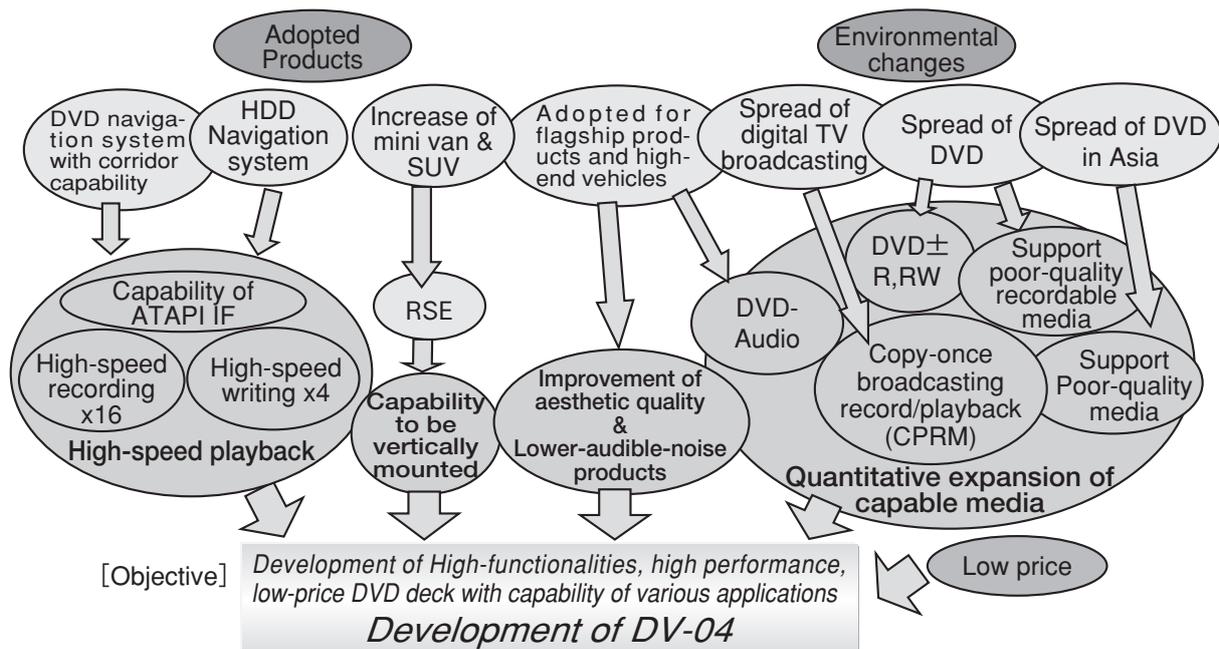


Fig.1 User requirements for the DVD deck

3 Overview of the System

DV-01NV was sold as DVD Video deck with ATAPI IF capability until very recently. (DV-03 did not come with ATAPI IF capability) However, these decks have been produced as DVD-ROM decks with video decoder capability, which means there was a need for a large number of components and high cost of production. We have cut a large number of components by simplifying the system for the newly developed DVD deck mentioned as follows:

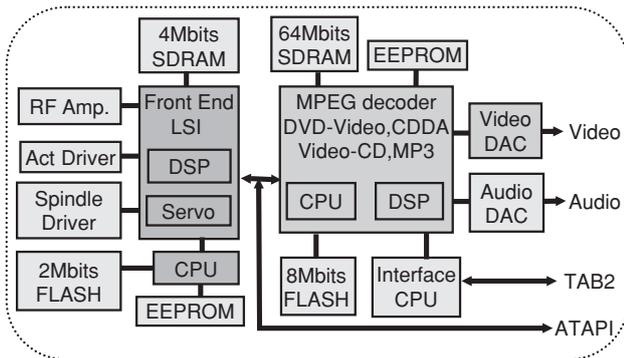


Fig.2 Block diagram showing DV-01NV

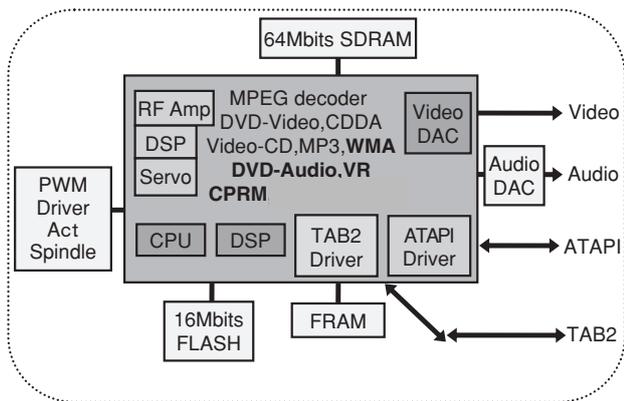


Fig.3 Block diagram showing DV-04

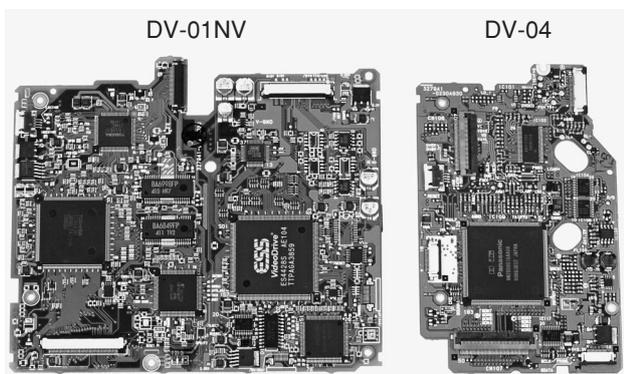


Fig.4 Comparison of main circuit boards

① Traditionally, DVD consists of a two-part structure: the front-end part that is in charge of data readout control/data transfer, and the back-end part that is in charge of coding the information for audio and video.

Both of the parts required CPU, RAM and ROM respectively, resulting in their large-scale circuit configuration. This time, the number of parts for IC, LSI are reduced from 15 to 6, as a result that we have developed a new single chip LSI that integrate front end and back end, in collaboration with a device manufacturer.

② Conventional products required the following two things. One is that it was necessary to equip specially-made microcomputers whose electric power is provided by BU power supply (full-time power supply), even at the time of video recording, in order to communicate with the host microcomputer of the navigation system on a steady basis. For this reason, conventional system was rather complicated in that three CPUs are communicating, whereas this time we have developed a system that one CPU with built-in single chip LSI is in charge of all processes. As single-chip LSI requires large electric power consumption, BU power supply is necessary. Therefore, FRAM, a high-speed non-volatile memory, is adopted, and storing of RESUME information becomes now possible. When BU power supply is not available, power to deck may be lost any time without warning, and once RESUME information become damaged, "MEMORY LOSS" would occur, which would be a fatal problem. In order to prevent this, double recording of each memory and a mechanism that can protect it from a power cut at any time, combining Checksum codes have been developed. This means that a system that does not require BU power supply has now come into a reality.

4 Capability of New Media

DVD is a format created in consideration of future extensibility, and thus, it is still expected to be capable of further new media and functions.

The following details show new capabilities we have developed for DV-04.

1) Capability of DVD Audio

In consideration of the cases that our DVD decks to be installed in luxury-model vehicles and premium audio systems, we developed a new product with DVD-Audio capability. As for the foundation of our audio circuit, we employed DAC (Digital to Analog Converter) format that supports 24bits at 196kHz, thus made it possible for high-quality analog audio output. There are some products that we must supply without the capability to play DVD Audio, thus, we adopted a system with a capability that customer can choose whether or not to make their DVD with DVD-Audio capability, with their use of a command control.

2) Compatibility with CPRM and VR Mode

These days, there has been a rapid spread of TV sets that supports terrestrial digital broadcasting. When a piece of digital TV broadcasting is recorded into a DVD-R/RW format, it has to be recorded (only once) into a VR format disc that is not compatible with DVD-Video discs but is not compatible with a copyright protection system called CPRM (Contents Protection for Recordable Media and Pre-recorded Media). Thus, the equipment that is

used for playback has to be compatible with both CPRM and VR format. In consideration of this situation, DV-04 supports both these formats.

3) Compatibility with Copyright Protection System

DV-04 is compatible with both CPRM and CPPM (Content Protection for Pre-recorded Media), a copyright protection system for DVD-Audio. As for the disc playback that is protected for copyright, a device key is used for playback before being played. These device keys must be recorded and their history shall be controlled correspondingly with product serial numbers, which have to be checked for recordings. However, our DVD products are manufactured overseas, and there will be multiple numbers of manufacturing bases due to the increase in the production volume in the future, which means it cannot be expected that a reliable control depending on individual personalities would be implemented. The copyright protection system needs secrecy, therefore, it cannot be mentioned in the paper in detail, however, we have developed the organization structure that we can control the device keys as a whole from Kobe Office without the need for local control anywhere around the world.

Table 1 Newly capable media and functionalities

		DV-01NV	DV-04
CD	CDDA	○	○
	CD-R/RW	○	○
	Video-CD	○	○
	MP3	○	○
	WMA	×	○
DVD	DVD (Single layer)	○	○
	DVD (Double layer)	○	○
	DVD-ROM	○	○
	DVD-Video	○	○
	DVD-Audio	×	○
	DVD-R/RW	×	○
	DVD VR	×	○
	CPRM	×	○
Video OUT	Composite	○	○
	Component	×	○
	Progressive	×	○
	Visual quality adjustment	×	○
	PAL→NTSC (Transformation)	△	○
Audio OUT	Analog 2ch	○	○
	Digital Multi Ch	○	○
	Dolby Prologic 2	×	○
	Bass Management	×	○
Operability	Direct touch operation	×	○
	OSD support for rear seat	×	○

5 High-Speed Playback

In Japan, HDD AVN that offers large capacity, high speed, and high user friendliness are mainstream products in the market, which generally used for recording CDs because of its large capacity. The recording speed of

HDD AVN is getting faster year-by-year, while DVD deck is required to playback at high-speed. Despite the trend, the popularity of HDD car navigation system is not spreading so rapidly outside Japan. This seems to be due to the fact that the contents of a DVD car navigation system can easily be updated or changed by replacing a map disc with another, whereas the contents of HDD cannot easily be changed, furthermore, establishing and maintaining service offices outside Japan is also difficult. This situation led us to be aware of the need for a capability to transfer DVD data to HDD car navigation system so that the map data can be updated.

The industry's fastest playback has now been added as a new feature of on our new DVD deck: DV-04. The details are as follows:

For CD: Max 16X variable-speed

For DVD: Max 5X variable-speed

This added capabilities have come true by adoption of high torque motor and optimization of servo design.

Transfer rate (variable speed)

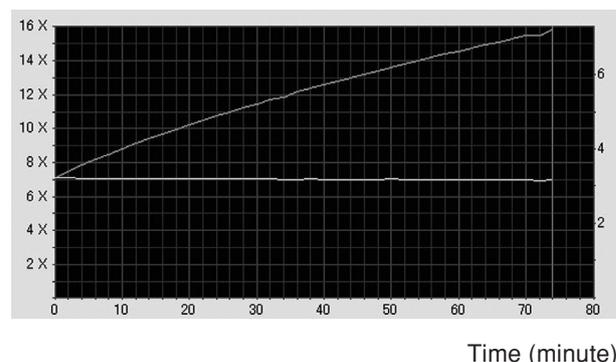


Fig. 5 16X variable-speed playback transfer (CD)

6 Suitability for Vertical Use

DVDs that are integrated into navigation systems or into rear-seat entertainment systems are required to be able to fit into many different places such as into trunks, arm rests, ceilings, or center consoles as well as to be mounted at many different angles. However, conventional in-vehicle disc-type decks have been structured in a way that the vibration is absorbed by separating the drive mechanical part from the fixed part, using a damper, during a playback. Thus, the suitable angle range for mounting was from -10 degree to 45 degree. Due to this fact, we could not respond to our customer requests to make our DVD decks suitable for vertical mounting. This time, we aimed at developing new DVD with suitability for vertical use from the beginning of our development process. In order to be suitable for vertical mounting, the center of gravity for the floating mechanism has to be maintained near the central area. We have optimized the design for a damper and a spring, while tuning repeatedly. This enabled us to ensure the new deck in vibration resistance equivalent to that of DV-04 even when vertically mounted, by adding 4 units of floating spring.

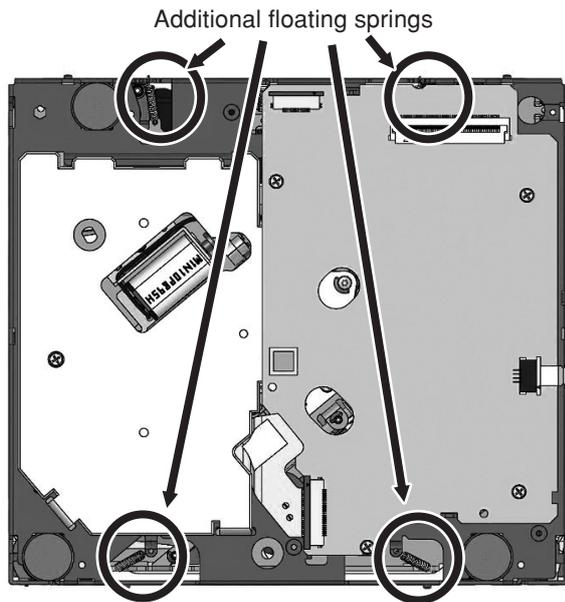
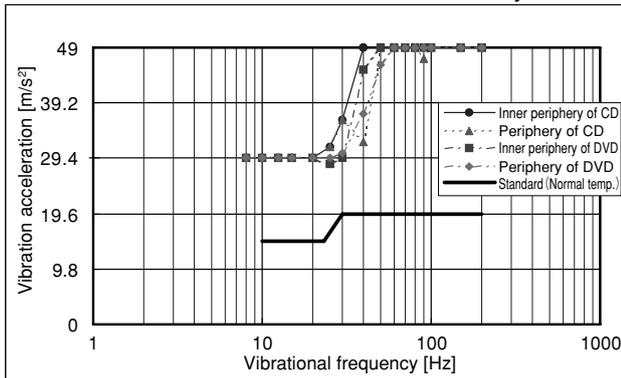


Fig.6 Floating spring for vertical mounting

Data on the vibration resistance when horizontally mounted



Data on the vibration resistance when vertically mounted

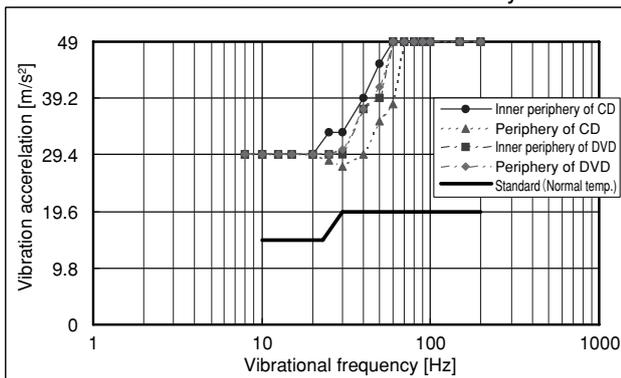


Fig.7 Comparison regarding vibration resistance

7 Noise Reduction Technologies

An increasing number of DVD decks are now shipped with high-end vehicles being equipped as a part of standard specification, and it is most likely that Lexus or other brands of luxury cars will be shipped with DVD decks equipped. The mechanical noise is be more

detectable in a vehicle space due to its closed environment, than in the open air, thus, a feeling of discomfort can be more likely to be felt. The automakers request towards their suppliers are getting higher year by year, while conventionally, we have always struggled to reduce the operational noise. This time, we have developed DV-04 with the aim to achieve the level of operational noise that is required for luxury vehicles. An issue of cost-saving was not prioritized over noise reduction for this development.

7.1 Reduction of Rotation Noise

The feature of DV-04 includes: variable-speed playback of 16X for CD and variable-speed playback of 5X for DVD, each of which is approx. three times higher than those of the conventional products, overcoming the fact that the rotation noise usually becomes bigger if the disc rotation speed is going up. When rotation speed is lowered, noise level becomes going down, therefore, usually, the achievement in quieter recording would result in giving up the capability of high-speed recording. However, we have tried to overcome this barrier, and aimed to achieve both in high-speed playback and quiet recording/placing.

7.1.1 Motor Drive System

We had already decided to adopt the PWM driver for new DV-04, from the start of this development, in response to our customer requirements on more efficiency in energy saving. However, adoption of the conventional PWM driver would result in the louder motor noise and more vibration due to the square-shaped wave pattern of its drive waveform. This time, we have adopted the PWM driver IC in sine wave driving waveform, for the purpose of reducing the noise.

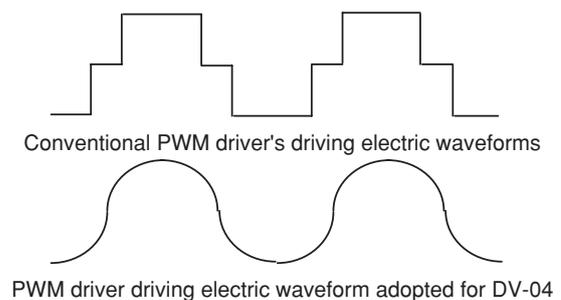


Fig.8 Comparison of driver waveforms

7.1.2 Motor with an Adhesive Magnet

Conventional motors were arranged so that the magnet does not come in the center of the coil. However, due to the fact that the magnet is not in the center of the coil, the motor vibration noise would become bigger when a disc is being rotated at a high speed or when the rotation speed is accelerated/decelerated, and that would then become detectable as an abnormal noise. We have optimized the structure by balancing the center of gravity of the motor and reduced the noise by adjusting the position of magnet to the same position as that of the center of gravity of motor. Moreover, we have added an adhesive magnet in order to bias the bottom side of the

motor's rotor portion, which enabled us to reduce rotation vibration and a quiet DVD has come into a reality.

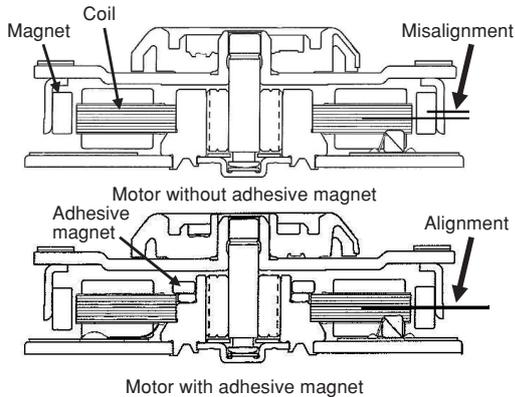


Fig.9 Comparison of disc motors

7.1.3 Motor Selection Using Benchmark Tests

We have selected the quietest motor among the three types available from different manufacturers, after conducting a benchmark evaluation. The evaluation was made in a way to repeat evaluations using physical data and sensory data, while suppliers of the motors also made more improvement on producing motors with much reduced noises. The benchmark tests were also conducted when selecting loading motors and PU slide motors, as we describe in the following section.

7.2 Reduction of Loading Noise

The motor itself and the motor vibration usually amplify a noise generated as a result of motor's rotation operation, until it would turn into an abnormal noise. The most effective solution to this problem is to reduce the rotation speed of motors. Below shows the countermeasures to reduce loading noise.

- The number of motor rotation has been reduced from 15,800rpm to 8,900rpm, by adopting a high torque motor that is large in size.
- The motor holder has been strengthened
- The number of gears has been reduced from 8 to 7 units.

The above measures contributed to the achievement in reducing approx. 10dB of loading noise.

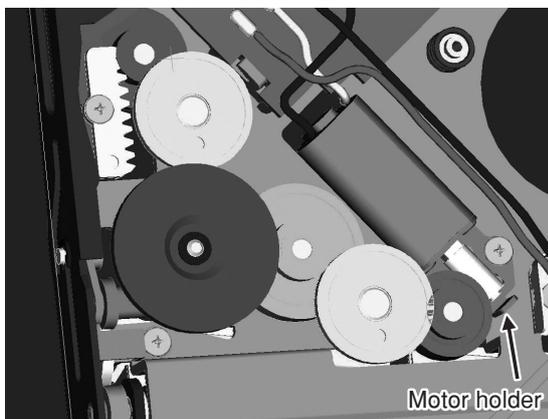


Fig.10 Loading mechanism of DV-01NV

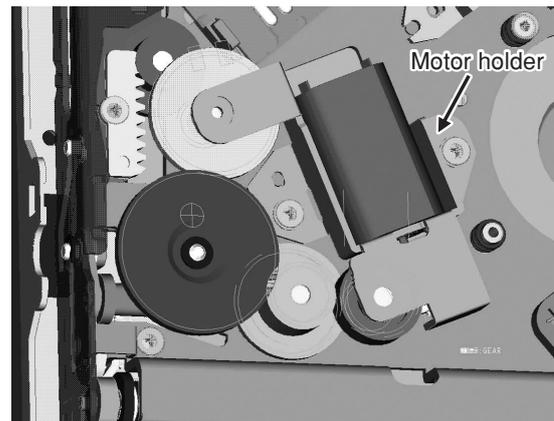


Fig.11 Loading mechanism of DV-04

7.3 Reduction of PU Slide Noise

We have conducted the following measures in order to reduce PU slide noise.

- The number of motor rotation has been reduced from 5,244rpm to 3,596rpm by extending the pitch between screws.
- A rubber-material was adopted for a disc-feeding stopper
- Spur gears have been replaced with helical gears

Those measures contributed to the achievement in reducing 6dB in PU slide noise.

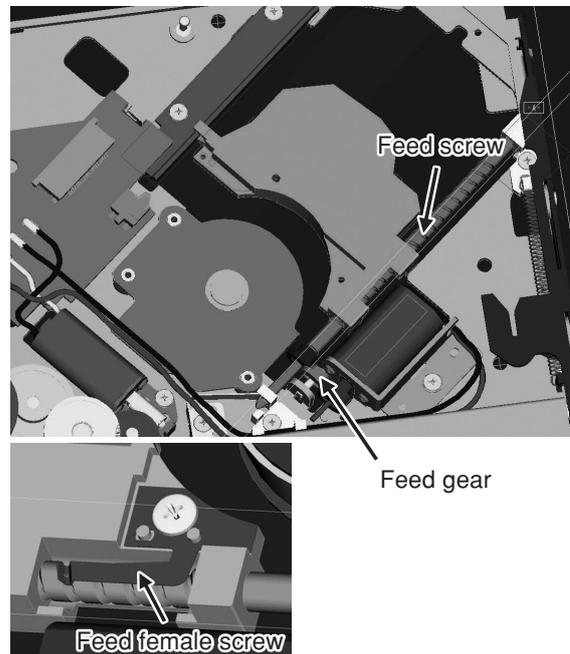


Fig.12 Slide mechanism of DV-01NV

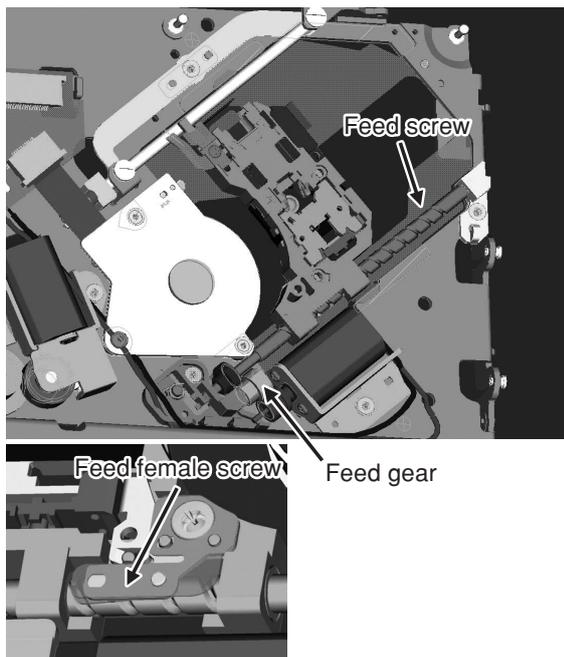


Fig.13 Slide mechanism of DV-04

8

Conclusion

As above, this paper has described an overview as well as some techniques we have developed for our new DVD deck, DV-04. Our AVN products have been sold with DV-04 from January 2006 for overseas market as ECLIPSE series, while the OEM products for automobile manufacturers have been supplied since April 2006. Furthermore, DV-04 has been adopted by several companies as OEM products, which seems to prove that we have developed the product aimed at the beginning. On the other hand, it is expected that the improvement of DVD in its functionalities still continue in the future, thus makes us more determined that we shall dedicate ourselves to put our efforts into the development of our next model with higher functionalities and higher performances, based on the know-how we have developed this time.

Lastly, we would like to mention the fact that we have received kind cooperation from our parts suppliers, design subcontractors, and OEM customers. We would like to take this opportunity to express our deepest gratitude to all those who were involved in our development of the new DVD deck for their kind association and technical support.

Profiles of Writers**Yutaka Matsunami**

Entered the company in 1991. Since then, engaged in the design and development of control circuitry for MD and DVD decks. Currently in the Deck Mechanism Engineering Department of Component Division, CI Group.

**Kouichi Ogawa**

Entered the company in 2001. Since then, engaged in the design and development of CD and DVD deck mechanisms. Currently in the Deck Mechanism Engineering Department of Component Division, CI Group.

**Hideaki Terada**

Entered the company in 2004. Since then, engaged in the development of DVD deck firmware. Currently in the Firmware Engineering Department Software Engineering Group.

**Yoshikazu Fujita**

Entered the company in 1989. Since then, engaged in the design and development of control circuitry for CD and DVD decks. Currently the Manager of the Deck Mechanism Engineering Department of Component Division, CI Group.