Development of Industry's Smallest MD Deck (MS-09)

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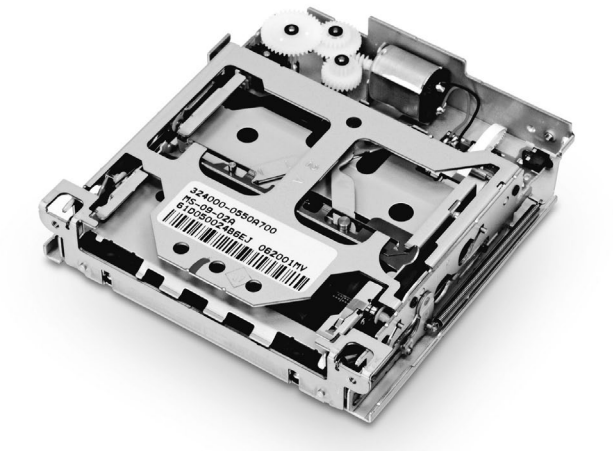


Abstract

Various kinds of MD decks, including both single-disc MD decks and MD Auto Changer decks have been mass-produced at Fujitsu Ten. The year 1995 was notable in that Fujitsu Ten began mass-production of the first-generation MD Auto Changer decks.

In developing our new MD deck (MS-09), we particularly put our efforts into the following two objectives:

1) To miniaturize our MD deck (MS-09) into "compact size", following the current demands in product structure to integrate as many components as possible into one unit. (e.g. AVN series)
2) To reduce the number of complaints called NTF (No Trouble Found), which accounts for a major part of overall customer complaints on the market.

This paper reports the method we employed and to what extent we have achieved these objectives.

1 Introduction

Fujitsu Ten released its first model of MD deck for in-car use in April 1995. Since then, the company's sales of MD products have grown rapidly, by supplying both for other audio manufacturers' products, and for our own products to have them equipped for in-car use (both as OEM products and as aftermarket products). Today, the company's production of MD decks has been largely increased, in parallel with the expansion of the MD market.

At the initial phase of the development of MD, 1DIN-size or 2 DIN-size audio equipments were produced; today, however, more products are produced as a part of navigation system, especially of AVN (Audio Visual Navigation) system.

For any components to be integrated into AVN products, downsizing and weight saving is important, and MD deck is not an exception. Although the conventional products are equipped with thin-type MD deck (Model number: MS-05), there is a need for smaller decks in consideration of current product configuration that multiple components are assembled into a piece of equipment.

This situation led us to develop the industry's smallest MD deck ever produced for in-car use. Meanwhile, the newly developed MD deck, MS-09, is a result of the pursuit under the current market demand for a MD deck, which can be integrated into any forms of products.

This paper shall describe an overview of MS-09 as well as its characteristics mainly from the aspects of functions and performance.

2 Basic Concept for Development

The following three development objectives were set forth when the development of MS-09 began.

1) Miniaturization: reduction of MD deck in all dimensions

2) Reduction of NTF: Implementation of error-code analysis

3) Improvement of readout performance: reinforcement of fail-safe system

・Previously, most of NTFs are "disc unreadable". This poor readout condition must be improved.

Table 1 Development specifications

Item		Newly developed product MS-09	Conventional product MS-05
Deck outside dimensions	Width	100mm	140mm
	Height	20mm	21.4mm
	Depth	105mm	109mm
Number of cases for NTF (including readout system)		50% decrease in comparison with conventional deck	—

Table 2 Measures to achieve the objectives

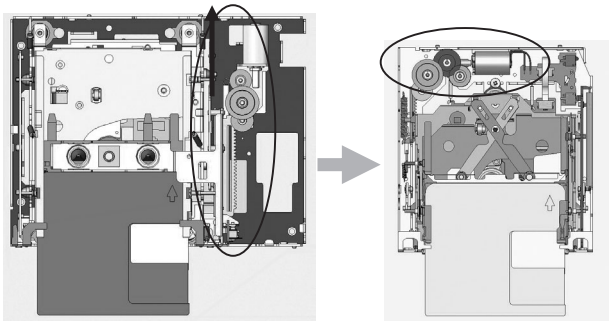
Item	Measures / strategies
1) Miniaturization	・Development of lever joint mechanism within minimum space ・Revision on height of floating lock at the time of disc insertion/ejection ・Layout change in mounted position in PCB
2) Reduction of NTF	・Improvement by extraction of low-occurrence defects by error-code analysis
3) Improvement of readout performance	・Reinforcement of fail-safe system

3 Miniaturization

3.1.1 Development of Lever Joint Mechanism in Minimum Space

One of our aims for the development of new MD deck this time is to reduce the deck's width and depth dimensions into minimum. In this section, our objectives and the measures shall be described.

The problem in conventional products was that they needed a large space in width and depth to be installed, due to the adoption of a 'rack and pinion' gears system, that the row of drive gears and the lever used for loading/unloading discs are arranged in the side part of the deck. As for newly developed products, the row of drive gears is arranged in the back part or the deck, in order to downsize the deck's width dimension. (Refer to Fig. 1)

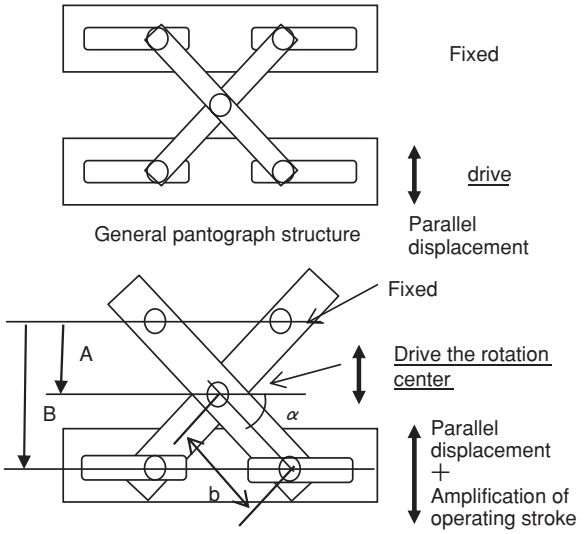


Conventional product (MS-05) Newly developed product (MS-09)

Fig.1 Revision over arrangement of the row of driving gears

However, in order to insert or eject quadrangular media, such as MD disc, there is a need for loading the media without spinning it around. Moreover, the pantograph structure was adopted for newly developed product due to the need that sufficient stroke force must be ensured for disc insertion and ejection. The pantograph structure generally adopted is the one that supports the parallel structure between one part and another. On the other hand, the newly developed product has a structure that possesses both operating stroke amplifier and a function of position determination to secure the parallelism by

driving the rotation center of pantograph lever in order to transmit a gear drive arranged in the back side. (Refer to Fig.2)



Pantograph Structure for newly developed products

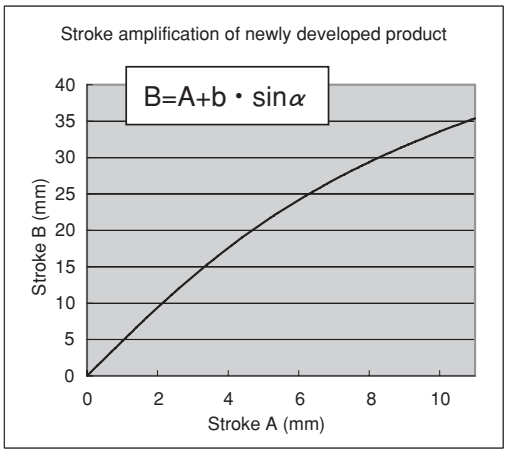


Fig.2 Pantograph mechanism

More specifically speaking, by joining rotation center of pantograph lever with clamper (holder to hold MD discs), the rotation center of pantograph lever can be moved back and forth, while both left and right arms of the pantograph lever are rotated, which means its stroking power are now amplified.

The MD disc inserting/ejecting mechanism with minimum dimensions is realized by the combination of 1) the raising/lowering lever for MD discs (The lever to be used for raising and lowering the disc at disc insertion/ejection.), 2) clamper, and 3) pantograph lever. (Refer to Fig. 3)

3.1.2. Implementation of Mechanism Analysis by CAE

When developing the lever joint mechanism for downsizing, the driving force shall be decided in consideration of operating load. However, the calculation becomes more complex, since the condition of the jointed part of the lever is changing every second. Thus, we have implemented mechanical analysis by CAE (Computer Aided Engineering), and analyzed the operation load changing at every stroke. (Refer to Fig. 4)

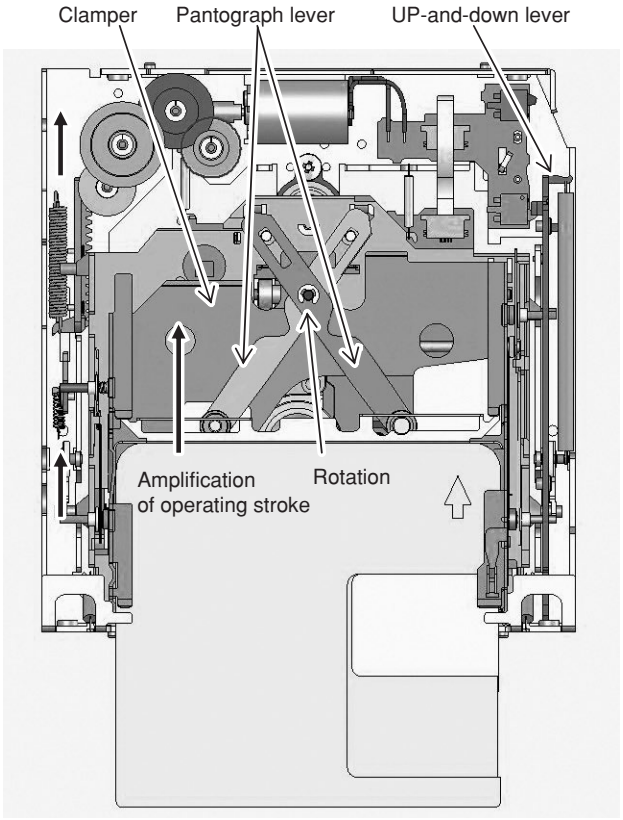
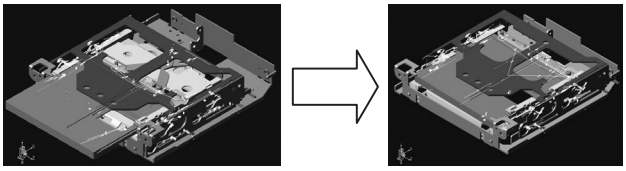


Fig.3 Inserting/Ejecting mechanism



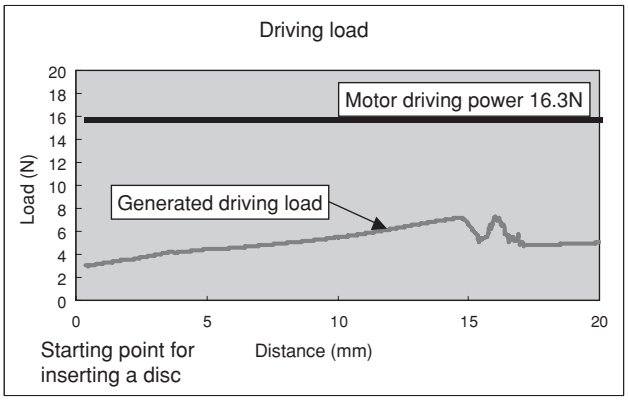


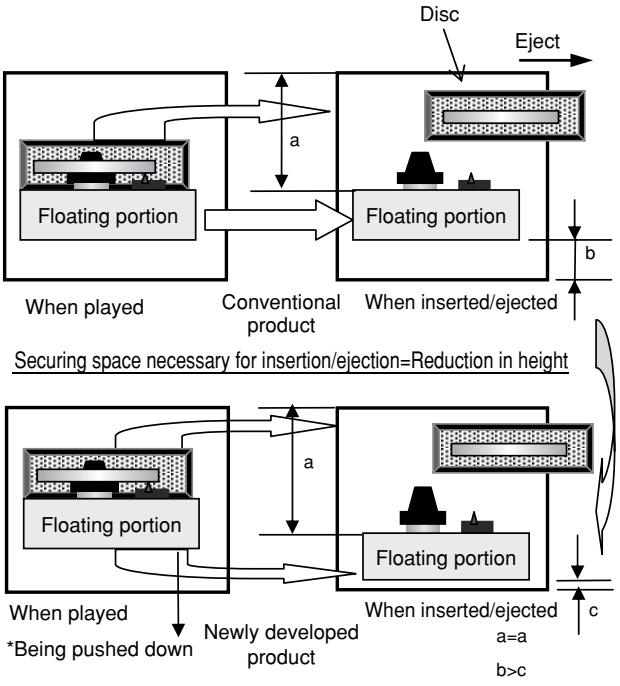
Fig.4 Results of driving load by mechanism analysis

3.2 Revision over Height of Floating Lock when Disc is Inserted/Ejected

Next, in order to reduce the height dimension of MD deck, we have used the space under the floating portion effectively. 'Floating portion' is a portion that a disc is loaded and played, while being supported by dampers in order to absorb vibration.

Conventional products use the space under the floating portion for vibration absorption, while maintaining the same height for the floating portion as the playback position using a locking system when inserting/ejecting discs.

Newly developed product does require the lower height for disc insertion/ejection since the floating portion can go down into a lower position and be locked at the lower position. This resulted in the reduction of deck's dimension in height. (Refer to Fig. 5)



*As the floating portion is pushed down, the space becomes available as a space necessary for disc insertion/ejection.

Fig.5 Height of Floating at disc insertion/ejection

3.3 Layout Change for Attaching Circuit Boards

Next, the reduction in width dimension and the method we used shall be explained. As for conventional product, the circuit board is installed in the right hand side of the deck, for this reason; however, the disc-loading slot is not in the center.

In order to reduce the width dimension of our new MD deck, circuit board is arranged at the bottom side of the deck. (Refer to Fig.6)

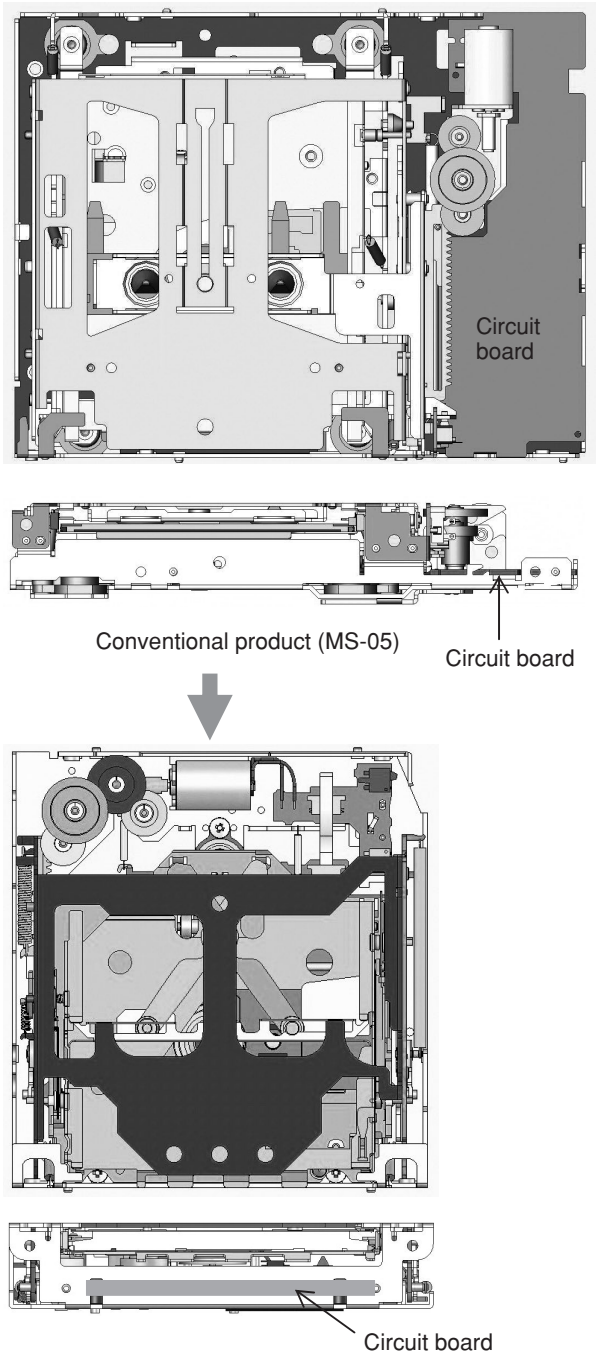


Fig.6 Layout modification of the board

When vibration is applied under the condition that the circuit board is fixed at the bottom side of a deck chassis, floating portion vibrates in three different directions on the circuit board, which requires sufficient space between mounted parts and the floating portion on the circuit board. However, if no measure is taken, height dimension will become bigger than that of conventional MD decks. This increase can be prevented if the circuit board is attached onto the floating portion. (Refer to Fig.7)

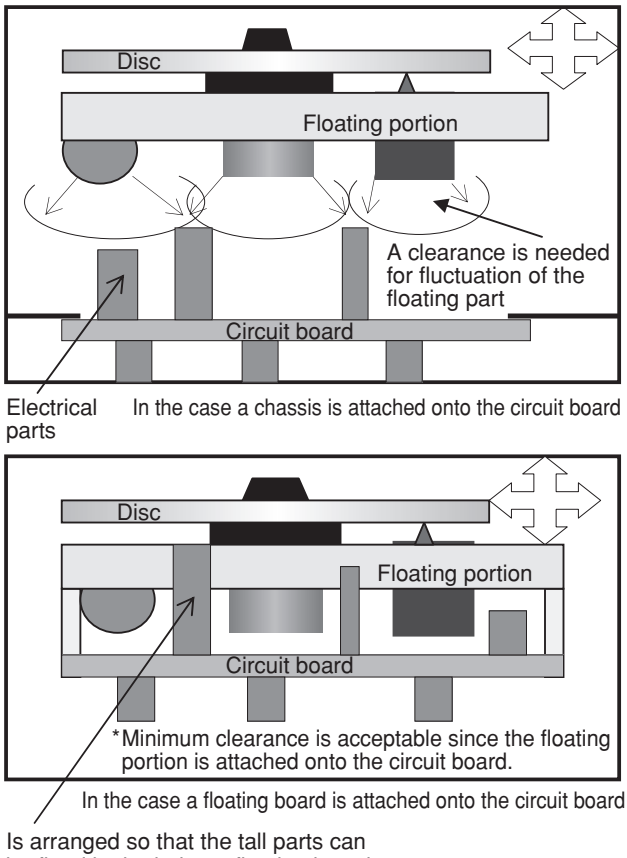


Fig.7 Installation of the board

In order to reduce the space between the floating portion and circuit board as much as possible, the tall electrical parts are fitted into the escape hole of the floating portion. Moreover, the small-size parts are selected for mounting on the floating portion (pickup, motor, gear parts) so as to prevent the height dimension to be higher.

4 Reduction of NTF (No Trouble Found) Failures

As a firmware function for newly developed MD deck, we have added more error-code functions, in order to eliminate the number of low-incidence defects and reduce the number of NTF (No Trouble Found) failures in the future. Furthermore, we have developed an analysis tool to improve the efficiency of our analysis; therefore, all mass-produced parts have to be analyzed at each development step with its operation history. This made it possible for us to extract any problems that may occur at early stages, while contributing to the reliability of our product quality. (Refer to Fig. 8)

Conventional products were designed under the concept that the error-code function are positioned only as debug function at the development stage, and 1 byte data would be recorded at the time of irregular stop. Therefore, it was difficult to determine exact causes for each market failure by linking with corresponding error information.

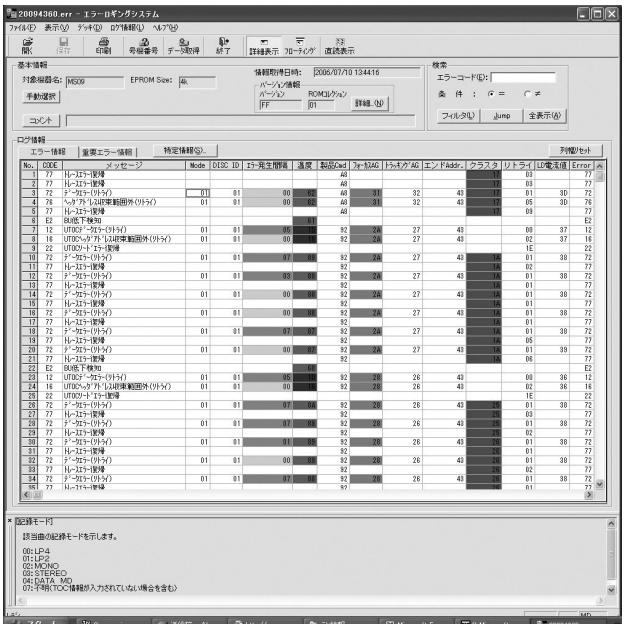


Fig.8 Display example of error codes using analysis tools

The newly developed product can record any abnormal operations at all processes respectively (design, development, evaluation, manufacturing, and market), while it was also extended to record more contents, such as disc information, temperature, laser current value, operating condition, in order to grasp the condition that the failure is avoided due to the activation of fail-safe system. Furthermore, it records each code to show each step such as deck manufacturing process and product manufacturing process, thus offers clear information on the stage of occurrence of each error information. (Refer to Fig. 9)

In order to prevent the product from being short of memory capacity due to the increased amount of information, ①a capability to analyze the pattern of abnormal occurrence has been added and ②the number of categories of error information has been increased (36→160),. These measures have led to optimize memory consumption, by enabling to write different amount of information (1～10byte) on a case-by-case basis for the respective error-codes. Furthermore, the memory devices are optimized in that the very important codes in analysis will be recorded in the new non-ring structure domain, which also contributes to offer information security. (A patent application with six claims with regard to this technique has already been filed.)

As a result of above development, both our objectives in ①extraction of low-incidence defects and ②improvement using error-code analysis have been achieved, which contributed to secure the product quality in early stage. Moreover, analysis tools were introduced to the relevant departments, which led to develop more effective system to analyze market failures.

00h	Reserved	
01h	Error code start writing address	(Upper level)
		(Lower level)
03h	Error code area 1 (356byte)	
166h		
167h	Error code area 2 (100byte)	
1CAh		
1CBh	Reserved (12byte)	
1D7h	Detected sound information 1	
1D8h	Detected sound information 2	
1D9h	Data error information	(Upper level)
		(Lower level)
1DBh	Detected information (BU)	
1DCh	Detected information (UTOC)	
1DDh	Reserved (0Ah byte)	
1E7h	Permission/prohibition of error code writing	
1E8h	Just before final access pointer	(Upper level)
		(Lower level)
1EAh	Error code 1: Access pointer	(Upper level)
		(Lower level)
1ECh	Error code 2: Access pointer	(Upper level)
		(Lower level)
1EEh	Process/market judgment	
1EFh	Reserved (04h byte)	
1F3h	P disc info.	(maxFEh)
1F4h	MODE-SELECT info.	
1F5h	Power current value1	
1F6h	Power current value1 Temperature info.	
1F7h	Power current value 2	
1F8h	Power current value 2 Temperature info.	
1F9h	Power current value 3	
1Fah	Power current value3 Temperature info.	
1FBh	Power current value 4	
1FCh	Power current value 4 Temperature info.	
1FDh	Information on accumulated time 1	
1FEh	Informatioin on accumulated time 2	
1FFh	Adjustment information	

Fig.9 EEPROM memory MAP

5 Improvement in Readout Performance

In the case of MD discs, market failures occur mainly due to the fact that users record them, rather than flaws or dirt. When the laser power for recording is decreased, jitter components on a recording disc becomes extremely deteriorated. When the jitter in the area of TOC (Table of Contents) is deteriorated, data in TOC becomes unreadable, and is expected to become impossible to start playing. When the jitter in the music-data recording area is in poor condition, sound skips or other abnormalities may possibly occur.

In order to improve readout performance for the discs that shows poor recording condition, the fail-safe system is now reinforced.

More specifically, when TOC data is unreadable under the default condition, the condition will be improved if the following actions are implemented:

①Retry a readout under the same condition
②Change the parameter that influences readout performance within the range of preset values for the LSI (Try values above and below the current value)
③Try jitter adjustment again
④Initialize the LSI and re-execute the respective automatic adjustment.

When not possible to read the region of music data, shockproof memory hours (when stereo recorded, 10sec.) becomes effective by implementing fail-safe system within memory hours, it would avoid sound skips without letting the listeners aware of the problem.

The quality of our MD deck is now improved in terms of readout performance, which is achieved by reinforcement of fail-safe system.

6 Conclusion

As above, this paper introduced a brief overview and structure of our newly developed MD deck, "MS-09".

We have achieved all three goals we aimed for this development: 1) miniaturization, 2) reduction of NTF failures, and 3) improvement on readout performance, while finally managing to introduce this product as our main force MD decks to the market from 2006-year models on.

Lastly, we would like to express our sincere gratitude for kind cooperation and guidance we received from the people who were involved in this development.

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Profiles of Writers

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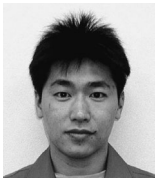
Entered the company in 1987. Since then, engaged in the design and development of control circuitry for cassette decks and MD decks. Currently in the Deck Mechanism Engineering Department of Component Division, CI Group.



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