AVN Development for '05 Summer Model

Tadashi Kidena
Kaede Motoyama
Takashi Eguchi
Yukio Shimizu
Masanobu Washio
Satoru Nagamoto
Taku Yokawa
Masatoshi Otani

Abstract

The Japanese domestic car navigation market is making firm expansion, with "Line installation" as its key word.

Since introducing AVN into the market in 1997, Fujitsu TEN has developed and expanded that AVN market, with an abundant lineup and highly innovative functions (DVD/CD/MD 3-deck in a unit, use of touch panels and film antennas, etc.).

However, in recent years, the entrance of competitor into the market has brought about even fiercer competition, causing a demand for further enhancement of commercial strength. It is due to this situation that Fujitsu TEN, in its efforts to make greater leaps forward with AVN, has developed the 2005 model, which we will introduce in this paper.

1 Introduction

The domestic car navigation market has been making smooth transitions. The after-market has been showing particularly firm growth, with extensive increases in the number of in-dash type AVN models and their emerging manufacturers (13 models of 5 companies in 2003 (16 models of 7 companies in 2004) owing to superiority in ease of installation, visual quality and theft prevention.

Additionally, in such a market of intensifying competition, it is vital for us to further differentiate ourselves from competitors and achieve product enhancement in order to lead other companies as an AVN pioneer. Here, we will introduce main differentiating functions, designs and technology for this purpose.

2 Outline of ECLIPSE 2005 model

In order to clearly differentiate ourselves from our competitors, we have made wide range changes particularly relating to design, and we have reinforced original functions.

2.1 Product concept

Vehicles evolve based on the key concepts of "safety", "comfort" and "environment". Fujitsu TEN is using its products to pursue such concepts within limited internal vehicle space, and is conducting planning and development with the aim of providing those concepts to customers.

While refining such efforts, we have sought the achievement of clear distinction between the competitors, and thus have promoted product development with the concept of [new AVN evolution].

2.2 Main product lineup

In the summer of 2005, we launched 6 new products: 3 HDD-AVN models and 3 DVD models.

Features in the new products include the following:

①Functions shared in common by all models:

- **Installation of 7 inch display**
- **Responds to terrestrial digital broadcasting tuner**

②Furthermore, with HDD model:

- **Installation of 4 multi-changers**
- **Constant quad-speed recording (all models)**
- **Use of FM de TITLE/new music information delivery service**

The following describes the outline of the new product main models.

(1) AVN8805HD

This is the first time in for us in the industry to install 4 multi-changers, thus achieving quad-speed recording. As another first in this industry, we have installed 7 inch VGA display in the 2Din type, and have allocated operating buttons in Active Wing. This helped us realize good operability and differentiation.

(2) AVN7705HD

This is an All-in-One model with consolidation of all HDD/DVD/MD medias, as well as with installation of 7 inch VGA display and Active Wing.

(3) AVN6605HD

This is a mass-market type HDD-AVN with installation of HDD/DVD. It includes installation of 7 inch EGA display, helping to achieve lower prices.

(4) AVN5505D

This is an All-in-One type DVD-AVN including DVD/CD/MD, as well as 7 inch EGA display.

(5) AVN4405D

This is a DVD-AVN with installation of both DVD video playing functions and 7 inch EGA display.

(6) AVN2205D

This is a mass-market type DVD-AVN at a downscale price, which also has installation of 7 inch EGA display.

Fig.1 AVN8805HD

Fig.2 AVN5505D

2.3 Main installed functions

By altering the core section of navigation, we achieved even greater graphic performance and processing speed, and have made wide-range function enhancements.

Altima engine

By integrating the microcomputer, graphic CPU, surrounding circuits and analog circuits into one chip, we achieved major imaging enhancements, implementing the following:

- Using 32,000 color simultaneous display and anti-alias process, which lets the screen show:
  ①Beautiful images of maps,
  ②Smooth images of roads, and
  ③Vivid and easily recognizable maps
- We have made further enhancement in HDD high-speed response. Route searches with gridlock forecast are performed at a previous speed of processing, even when database information quantities exceed those seen in previous models. This aids in achieving stress-free processing for destination and route searches.

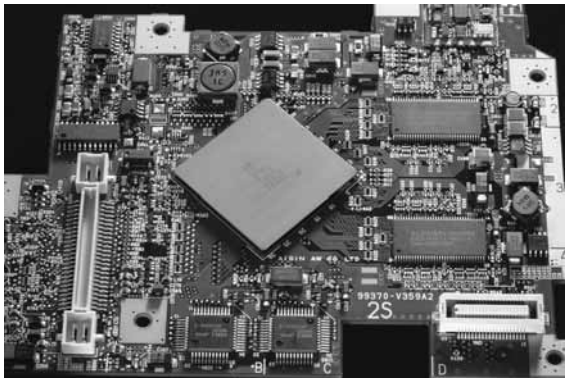

Fig.3 Ultima engine

Gridlock-free route search

It is now possible to establish records in navigation for "previously accumulated gridlock data" and "new gridlock data", and to conduct optimum route searches using gridlock information. And, by learning from gridlock situations on the roads traveled and using that information as a gridlock-free search database, precision in gridlock judgment has been enhanced.

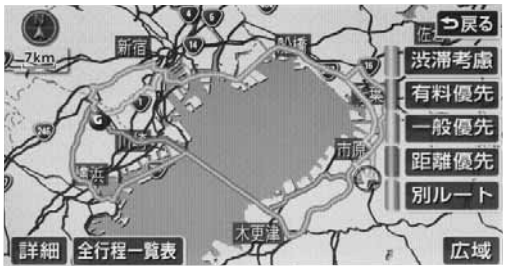

Fig.4 Gridlock-free route search screen

Area search refinement

When inputting place names (with Japanese alphabet) for destination searches in the past, it was necessary to go through 5 procedures in order to search for a certain facility. These procedures included selecting the area (municipality) after entering the name of that facility.

Now, however, with just one touch of a button it is possible to narrow down and refine searches in the prefecture the car is located in. This simplifies search procedures, and enhances operation.

Fig.5 Area search refinement screen

Highway pattern diagram guidance

We now have a function which displays pattern illustration only for national highways. It is possible to show map displays, VICS information displays and 4 stage reduction scale switching, which make highway ICs and JCTs easily understood at a glance. This capability aided in improving the convenience while driving on highways.

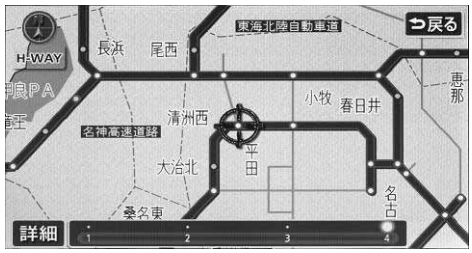

Fig.6 Highway pattern diagram

Detailed city road guidance

We have created a function for automatically switching to a 2 screen detailed map display for when the vehicle travels on complicated roads during route guidance. With this function, guidance can be done with easily understood displays even when one is lost.

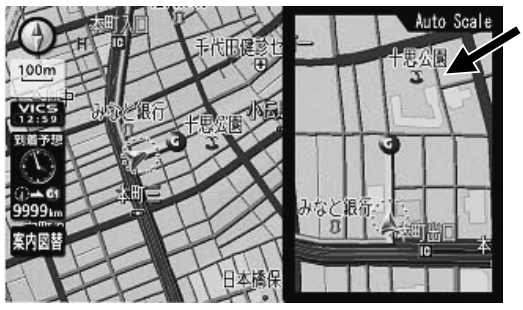

Fig.7 Detailed city road guidance screen

3 Design

Ever since Fujitsu TEN's development of AVN in 1997, we have constantly continued to achieve firsts world-wide and business-wide. These achievements have included not only those with AVN, but with products such as touch panel in 2001, TWIN-HDD in Fall 2002 and

Dual Face in 2003. Since the restriction of 2DIN size, 6.5 inch display had been the mainstream for market AVN. However, in 2003 Fujitsu TEN have developed an AVN with 7 inch retractable display based on "the Dual Face concept", thus responding to the market demand for even a slightly larger screen, and made products commercial.

In 2004, a competitor established 7 inch model through a fixed panel. This created motivation in the market to make an immediate aim towards the concept of "Screen size evolution = 7 inch model." However, with limited frontal space, establishing 7 inch model with fixed panels in the after market would mean a major sacrifice of operation performance. Therefore, Fujitsu TEN solved this problem with Active Wing, aspiring for "new AVN evolution." Active Wing is a model which has greatly changed the previous concept of AVN. It is superior not only in terms of enhanced operation and visibility, but also in terms of its novelty.

If a change is made from model 6.5 ("Evolution of screen size") to model 7.0, as previously stated, there is almost no space available for operation. Furthermore, with previous button layout the operating user ends up covering the screen with operator's hands. Active Wing eliminates the previous concept of buttons in a row on both sides of the screen. By instead arranging buttons horizontally on the bottom portion of the main body, the operation area reaches almost 150%, a natural sense of operation is created, and "evolution of operation" is achieved. Putting this larger operation area to good use has enabled "button layout ingenuity." (layout of frequently-used buttons on the driver side/button design aiming for eye-catching effect) [refer to Figure 8]

Fig.8 Active Wing button layout

With this Active Wing, the user can choose the angle of operation with an operation panel separate from the 2Din main body. This allows for a number of merits, such as: ①Capability to install 7.0 display, ②Enhancement of operation and visibility, ③Distinction with genuine product design, and ④Appeal with customers at shops.

An additional dual visual effect (mold design) happens when Active Wing is opened and closed. When opening, we can see gorgeous commercial design, and when closing Active Wing blends perfectly into the vehicle interior. When using navigation, Active Wing is usually left open; however, the driver will not necessarily always be using navigation. In situations such as using only AUDIO without the screen, the user can close Active Wing when its operation is not necessary. This has resulted in a more refreshing vehicle interior environment.

For "GUI evolution", in map display we have achieved: ①32,000 color display [refer to Figure 9], ②Smooth road images without blurriness [refer to Figure 9], and ③Real 3-D building images [refer to Figure 10]. In regards to the interface, we have achieved evolution in terms of: ①Use of simple pictorial icon [refer to Figure 11] and ②Visual display that guides the user in operation [refer to Figure 12]. Also, taking after the opening/closing setup for Active Wing, we have also made DISC insertion and ejection simpler with a layout in which touch switches are located above the screen. [refer to Figure 13]

Map display

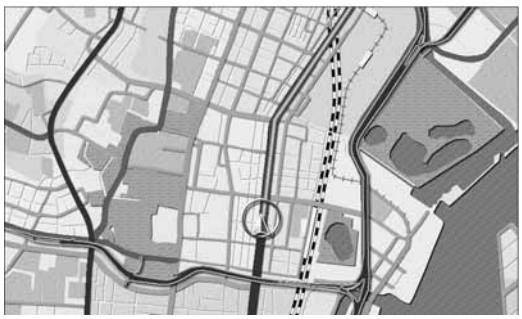

Fig.9 Road display

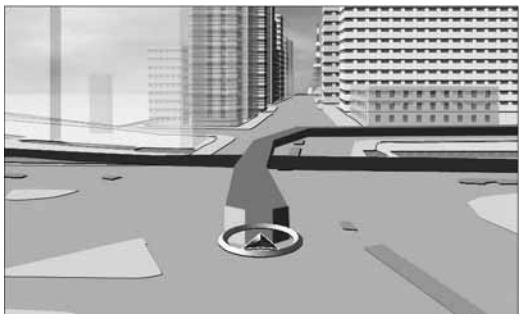

Fig.10 Real 3-D building display

Interface display

Fig.11 Pictorial icon

Fig.12 Visual expression

When closed

When opened

Fig.13 DISC eject screen

We firmly believe that development of products as stated above which set us apart from other companies will give "ECLIPSE" brands greater presence in the market, and we will continue from here in our challenges for "new evolution."

4 New technology items

4.1 Regarding development of Active Wing

As described up till now, in our present development we have not only installed model 7 TFT to the after-market size AVN, but are also conducting development of new Active Wing as a completely different system of operation. Although enlarging TFT has enabled enhanced product marketability, housing within a "2DIN" size space is an absolute requirement for loading of car-installed audio products, further limiting space for configuration design. In terms of installing Active Wing operational mechanisms, this means an extreme increase in design difficulty. What makes matters even more difficult is that, in terms of preserving marketability we need to consider design demands such as slimming of Active Wing thickness and enlargement of operation buttons, as well as fail safes for Active Wing handling. The following describes our technical measures for achieving the functions and performance required in such limited space.

(1) Internal configuration

Active Wing is located on the lower surface of the display panel surrounding the screen, and for the rotation center of that panel, it has a motor-powered automatic open/close function.

With normal mechanism designs, it is common for the operation panel to be moved with installation of the operating mechanism in the display main body (the fixed portion). However, this installation is extremely difficult within the restrictions of simultaneous installation with 7 inch TFT. To solve this problem, we changed our thinking with this model, and put a compact motor and speed reduction gears inside Active Wing (the movable portion).

When facing the Active Wing internal layout, we can see the installation of drive mechanism parts such as the motor on the left side, parts connecting with the fixed portion in the center, and angle a control sensor on the right side (Figure 14). We made detailed layout with consideration of design, to calculate the optimun gear combination for panel slimming (12.5 mm) and the torque necessary for panel opening/closing. Also, the internal parts layout greatly affects speed differences in opening and closing. Therefore, to reduce moment during rotation, we set heavy parts such as the motor as close as possible to the rotation center, which helped to minimize effects on opening and closing speed.

Fig.14 Active Wing internal structure

(2) Ensuring of durability through use of highly rigid material

Active Wing greatly protrudes out from the front of the display area Thus, when using the buttons a considerable burden is put on the connected area to the display mainframe and on the Active Wing panel itself, which causes concern for quality reduction due to bending. With present technology, it is difficult to secure space for increasing rigidity under these structural restrictions. Because of this, we set our sights on a rigidity raising process through a combination of reinforced resins and electrolytic plating. The reinforced resin which contains a mixture of PC/ASA and carbon fibers (CF) are used. By coating the resin surface with non-electrolytic undercoat

plating (Cu) and electroplating(Ni), we attained strength and lightness equivalent to that of magnesium alloy (Table 1). This enabled us to reduce the amount of flexure (bending) during operation by approximately 1/6 of that with regularly used resin material PC/ABS (Table 2). In addition, for gears with no allowance for strength, we achieved miniaturization by using sintered alloys.

Table 1 Property comparison with Magnesium alloy

Material	Bending elastic modulus (MPa)	Flexural strength (MPa)	Specific gravity
Mg alloy	33700	330	1.82
PC/ASA+CF10% Electroplating (35μ)	33600	390	1.50

Table 2 Comparison of deflection and load for each material

Material (plate thick)	PC/ABS	PC/ASA +CF10%	PC/ASA +CF10% (20μm)	PC/ASA +CF10% (30μm)
Load	25N	70N	80N	150N

(3) Angle control method

Sensors are needed for Active Wing angle control. In this model, a spiral-shaped groove is set into the panel rotation central shaft, and a linear position sensor is used to detect the location of pins sliding along through that groove. In this way, software reads sensor voltage to control the panel location. In order to control the panel movement precisely or roughly, angle of the spiral-shaped groove is changed depending on the area where precise control is required or rough control is required. (Figure 16. Patent pending.)

Fig.15 Active Wing angle setting (angle of panel to screen: 0 ° when closed, 150 ° when open)

∗From 90° to 150°, 7-stage setting possible at 10° intervals.

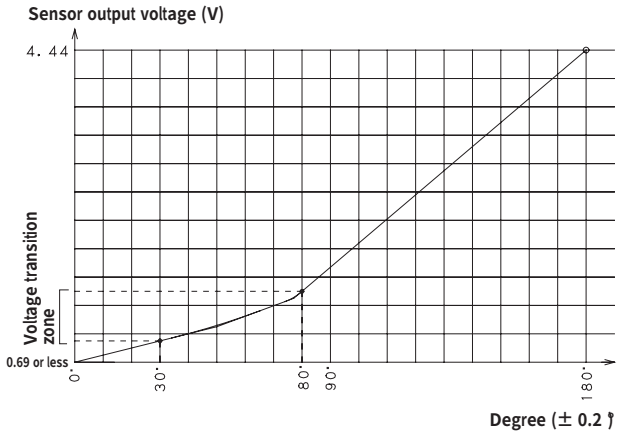

Fig.16 Control curve for linear position sensor

∗Reading configuration settings are at 0° to 80° for rough control, and at 80° to 150° (MAX 180°) for high precision.

(4) Failsafe

It is a concern that, when using Active Wing buttons, it will not be possible to ensure internal gear strength due to the small size of their teeth and that those teeth could break from loads or external shocks exceeding gear strength. As a countermeasure to deal with this situation, Active Wing houses a clutch mechanism in which a ratchet-type clutch is configured for sliding. This acts as a failsafe in case force is applied (approx. 20 N) going beyond the estimated gear strength. The reason for using a ratchet-type clutch is to make it unnecessary to perform reverse operations seen in regular clutches. Instead, the clutches engages at various positions after their release. However, for the user, it is easy to mistake clutch release operations as a breakdown mode. Therefore, Active Wing uses readings done by the previously mentioned linear position sensor of absolute angle values. In this way, even if the clutch slips, software control is done to return the clutch to its last position. This allows the user to conduct operations free of worry.

4.2 4 disc multi-changer

Disc media is becoming more and more diversified, with examples such as DVD video, MP3 and WMA. All of those involve 12cm discs, and there has been a demand for improvement of their convenience for product use in playing.

For such disc media, we have developed a multi-changer deck capable of multiple disc storage, which has enabled wide range enhancements of use. Examples of these enhancements include GUI which can quickly identify the media of the disc(s) stored, , and the ability to record 4 discs in succession without having to change discs one by one during recording through the Music Juke function.

Fig.17 Simultaneous 4-disc display screen

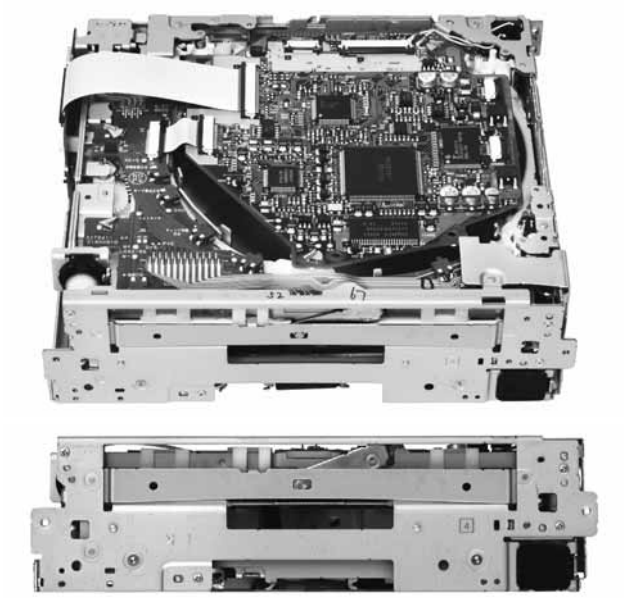

Fig.18 Multi-changer deck (single view & front view)

4.3 New music information delivery service

This function is capable of receiving information on new music (jacket pictures, album titles, recorded song titles and contents, etc.) transmitted through FM multiple broadcasts. Models from and after 2004 have dealt with a "FM de TITLE" function which receive information from CDDB using multiple broadcasting. This broadcasting service, the first of its kind in the world, was made a reality by FUJITSU TEN, developer of terminals for transmitted data reception, as well as by record companies providing new music information, Media Click Inc. which produces transmission data, and FM Tokyo, which transmits data by multiple FM broadcast. With this service, it is possible to receive through JFN affiliation, at no charge, information on as many as 50 albums a week.

Also, through the FM de TITLE function, it is possible not only to receive title information for the recorded albums, but also to display their jacket photographs.

Fig.19 Music Juke screen, including jacket pictures

Fig.20 Information screen on new music title

Development for these functions and services was done keeping the following points in mind:

①Convenience

In the past, in order to obtain information on new music, had to go through a number of hassles, such as going to CD shops to get free newsletters published by record companies and checking information on the Internet. However, such individual collection of information is no longer necessary, for with this service this information can be sent to users through FM multiple broadcast.

This is beneficial for record companies as well, as this service enables unprecedented promotion activities.

②Affiliation with previous FM de TITLE service function

Until recently, CDDB information has been transmitted through the FM deTITLE function, which also requires linkage with the album. However, with CDDB information added to this transmission service, the amount of data increases, as does the time required to receive it.

By linking with the previous FM deTITLE without sending CDDB information through the transmission service for new music information, the amount of transmitted data has been kept to a minimum, reducing time required for reception.

4.4 Achievement of the 1 HDD quad-speed model

With the 2004 model, 2 HDD configuration helped to attain quad-speed recording functions. This model has 2

HDDs for navigation and Music Juke, which have prevented access competition and assured performance in writingprocessing from CPUs. In addition, last fiscal year we developed the 1 HDD model, which hadn't yet existed the year before. This was made possible by making the HDD host into two microcomputers for navigation and Music Juke, and by performing changover between ATA Buses. Based on this process, in 2005 we developed 1 HDD+ quad-speed recording.

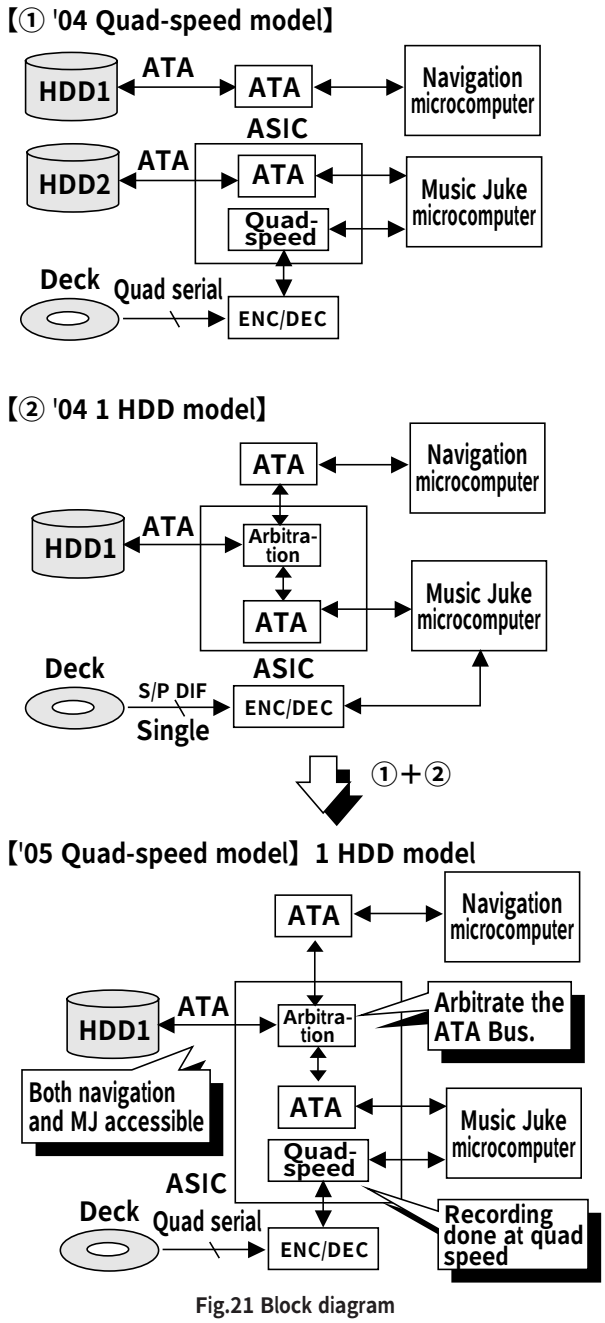

Fig.21 Block diagram

Merely combining the quad-speed model system with the 1 HDD model system would result in an increase of conflict with HDD access compared with the 2004 model, causing degradation of response in map data reading and recording data. It is believed that this would bring about defects such as broken sound in recorded data and delays in navigation guidance.

[Examples of HDD access competition]

'04 1 model =MJ recording + navigation map reading

'05 model =MJ recording + MJ play + navigation map reading

Through a study of 2004 model HDD access, we found that longer time was required for HDD writing processing. By enhancing this processing, we ensured its performance and attained the present system.

①Use of HDD Write Cache

By turning on the cache during date writing to HDD, we were able to reduce loads on microprocessor processing.

②Use of Flash Cache function

When power is turned off during HDD Write access, simply turning on the Write Cache does not ensure data input. By using the HDD's Flash Cache function, however, we were able to protect data even when the power was turned off.

③Difference in use between Write Cache/Flash Cache

While it is possible for Flash Cache to protect data, writing performance is reduced. This is because constantly having Flash Cache turned on results in an increase of conflict with navigation processing access. With the 2005 model, the Flash Cache function is used only for recording termination processing which requires data protection, and the Write Cache function is used during other writing processes. In this way, we were successful in tackling both writing performance enhancement and data protection.

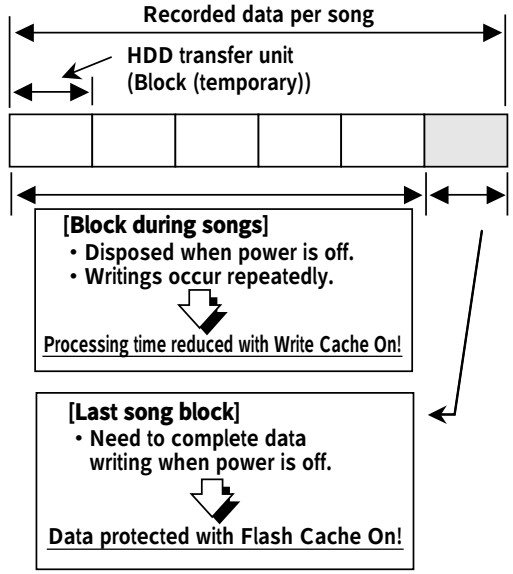

Fig.22 Different cache uses

4.5 Efforts for HiFi sound

With previous AVN configuration, audio from CD/DVD had been D/A converted to input in DSP.

In recent years, to respond to market demand for AVN with HiFi sound, "digital direct-in" was installed in the 2005 AVN model. Digital direct-in makes completely digital connections in the HDD model without sound quality deterioration, from the deck to D/A converter output via DSP.

The following is the configuration figure. In HDD-AVN, the clock master device for audio processing is in Music Juke. Because of this, when directly connecting output from the deck to DSP, audio is not synchronous and cannot be output. There would be no difficulty in solving this problem if DSP were temporarily reset and if deck output was made to be the master. However, DSP cannot be reset, since as of the 2005 model DSP performs volume adjustments for navigation audio. Therefore, before inputting into DSP, clock synchronization with the master device was made via SRC (Sample Rate Converter). Doing this helped to achieve digital direct-in configuration.

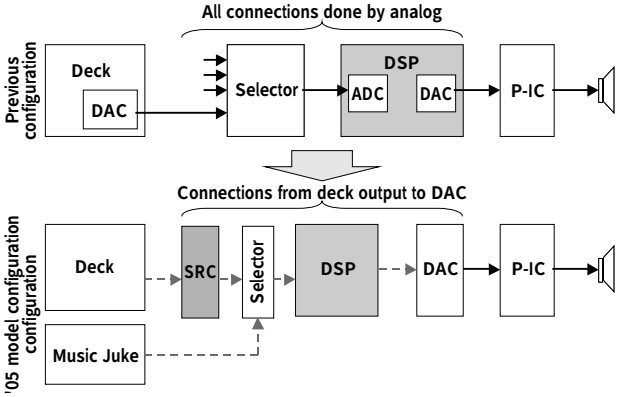

Fig.23 Comparison of previous and '05 model configurations

4.6 Efforts for miniaturization

For AVN8805 which holds the multi-changer deck, a deck which is wider, deeper and higher than the previous DVD single deck is installed. Due to this, configuration of the printed board was changed. (Figure 24)

It was found that, as a result, surface area usable for PC board mounting was reduced by approximately 220 mm^2, and moreover that approximately 1,200 mm^2 of space is necessary for addition of new functions.

For this model, we newly developed and installed DSP (AK7746). This includes the following 3 devices: ① Analog audio selector (IA) from the previous model, ② DSP, which performs data processing for SFC (Sound Field Control) and EQ (Equalizer Control), and ③Memory for time delay (SRAM). (DSP AK7746 installed in all aftermarket models.) However, improvements were made to

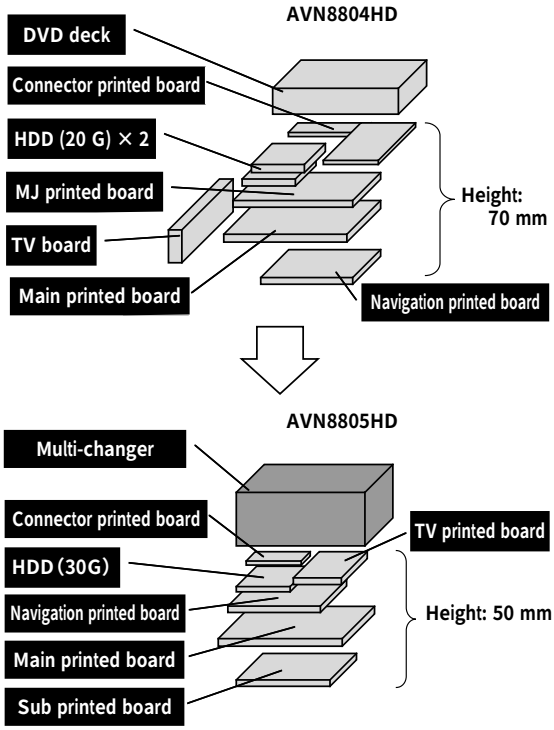

Fig.24 Printed board layout of '04 and '05 models

limit interference within the DSP chip and to faithfully recreate original sound. This was done by externally attaching the DAC (DA converter) formerly located inside DSP,

By making this DSP1 chip, we were able to reduce the surface area for printed board mounting by approximately 60% (approx. 1,800 mm^2).

In addition, we consolidated interface general purpose logic from among devices using PLD. Because of this, we were able to reduce costs and increase the reliability of our products.

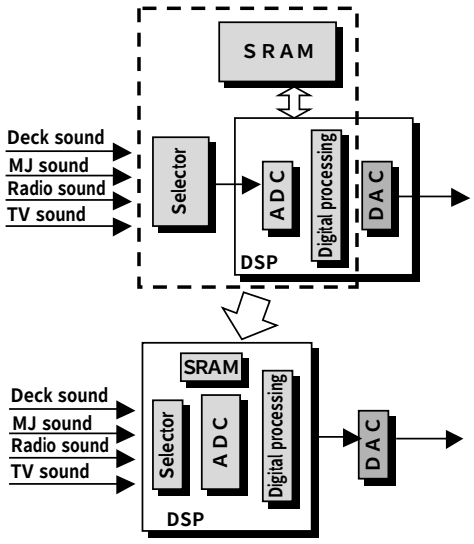

Fig.25 Comparison of '04 and '05 models (block diagram)

Table 3 Comparison of '04 and '05 models (mounting area)

(mm^2)

Models	AVN8804HD	AVN8805HD
DSP	1190(AK7720)	900(AK7746)
SRAM	195.5	Not used (built-in)
IA (selector)	1800	Not used (built-in)
DAC	Not used (built-in)	420
Total area	3185.5	1320

5 Conclusion

When AVN type navigation products from competitors appeared one after the other in the market, we configured a lineup for the 2005 after-market models to set a clear distinction between us and those companies. This line-up includes newly developed pillar items such as installation of model 7 display for all models, use of Active Wing, and use of the DVD multi-changer.

Also, user needs are becoming more and more diversified. Criteria to be considered in product selection has come to include not only pursuit of multiple functions but also sensual elements such as design, operation performance, and sound quality. We feel that our continued use of approaches unheard of in other companies is what has given us our present pioneering status, in the form of AVN.

It is our hope to continue development of products of high quality function and performance which match market needs.

Profiles of Writers

Tadashi Kidena

Entered the company in 1986. Since then, has engaged in AVN development by way of car audio circuit design and LSI development.
Currently the Department General Manager of the Engineering Department of Engineering Division 2, Business Division Group.

Kaede Motoyama

Entered the company in 2002. Since then, has engaged in AVN appearance design development.
Currently in the Products Planning Department of Engineering Division 2, Business Division Group.

Takashi Eguchi

Entered the company in 2003. Since then, has engaged in AVN system development.
Currently in the Engineering Department of Engineering Division 2, Business Division Group.

Yukio Shimizu

Entered the company in 1984. Since then, has engaged in development of AVN structure/drive mechanism by way of mechanism design of radio.
Currently in the Mechanical Engineering Department of Engineering Division 2, Business Division Group.

Masanobu Washio

Entered the company in 2002. Since then, has engaged in AVN hardware/software development.
Currently in the Engineering Department of Engineering Division 2, Business Division Group.

Satoru Nagamoto

Entered the company in 1991. Since then, has engaged in product planning operation for navigation and audio related products. Currently in the Products Planning Department of Engineering Division 2, Business Division Group.

Taku Yokawa

Entered the company in 1995. Since then, has engaged in AVN software development by way of navigation hardware/software development.
Currently in the Software Engineering Department of Engineering Division 1, Business Division Group.

Masatoshi Otani

Entered the company in 1989. Since then, has engaged in navigation equipment development by way of audio equipment development.
Currently in the Mechanical Engineering Department of Engineering Division 2, Business Division Group.