Development of Autumn 2003 Model ECLIPSE AVN9903HD

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GOOD DESIGN AWARD

Satellite images provided by Japan Space Imaging Corporation.

Abstract

The car navigation market has been expanding rapidly for several years, leaving the sluggish car audio market in the shade. In 1997, FUJITSU-TEN gave the market the world's first AVN (Audio Visual Navigation), which since then has undergone continuous evolution to meet customers' wide-ranging needs as media have evolved.

Meanwhile, constraints on dashboards have become ever more severe with the advent of passenger seat airbags, central deployment of meters, etc. Additionally, there has been a sharp increase in car break-ins and theft of navigation systems, a trend that is detrimental for hideaway navigation. Accordingly, our competitors too have begun launching AVN, so that it is rapidly achieving a more visible profile.

This paper introduces a new type of AVN incorporating a 7-inch screen, which has been developed in order to keep ahead amid the intensifying competition.

1 Introduction

The car navigation market has been expanding for several years. Initially the majority of car navigation equipment had its display unit on the dashboard. But more recently a trend has emerged for equipment to incorporate features to counter the dramatic rise in car break-ins, and coupled with a preference for visual appeal. This has resulted in a surge in the proportion of in-dash-board type equipment and the integrated equipment known as "AVN".

In response to such trend, the various companies in the field have all begun to participate in the AVN market, and competition has been intensifying. In order to achieve differentiation from competitors, we have engaged in AVN planning and development employing new concepts that constitute a department from what we have done before.

Fig.1 AVN9903HD when closed

2 Overview of the product

Below is an overview of the ECLIPSE Autumn 2003 model "AVN9903HD". In broad terms it consists of a common component, a display component, an AV component, a navigation component, a sound quality component, and system enhancement equipment.

Common components

- External dimensions: 2DIN (W 178×H 100×D 165mm)
- Mass: 4.0kg approx.
- Deck: DVD/CD compatible deck
  HDDs: 20GB HDD for navigation
  20GB HDD for audio
- Control operation: Touch panel + front panel switches
  When display is open: operation via front panel switches
  When display is closed: operation via remote control

Display components

- 7-inch VGA wide display
- Screen size: W 156×H 83 mm
- Number of pixels: 1,152,000 (horizontal 480×vertical 800×3)

AV components

- Radio (AM/FM/FM multiplex)
- TV (multi-channel capability for channels 1 - 62)
- CD player (CD-R/RW compatible)
- DVD video player
- MP3 player
- Magic Gate compatible memory stick music player
- Music Juke (able to record up to 3,000 tracks)
- CDDB (with auto-titling function)
- VTR input, rear seat monitor output

Satellite images provided by Japan Space Imaging Corporation. JSI

Fig.2 AVN9903HD when open

Navigation components

- HDD navigation
- Equipped with new navigation engine*1
- Equipped with 3D hybrid sensors
- Satellite shot capability (continuous zoom / landmark name indication / route guidance)
- Capable of constant FM-VICS reception
- Multi-window functions

Sound quality components

- Sound field control / graphic equalizer / position selector
- Built-in 5.1 channel surround decoder
- Built-in 50 W (4 channel amplifier

System enhancement equipments

- CD changer (twin CD change capability)
- MD changer
- Center speaker
- Sub woofer
- 2-media VICS unit
- ETC unit
- Backeye camera
- 10-key remote control

(*1) Navigation engine: CPU that controls the navigation component.

3 Major features

3.1 Design

Since its launch by our company in 1997, AVN has been evolving year by year - in 2001 it acquired a touch panel, 2002 saw the appearance of the VGA high definition model, while the autumn of that year brought forth an HDD model. And with each year the market's appraisal of AVN has risen dramatically. Given such background, we examined on-dashboard car navigation systems, which enjoy the lion's share of the market, to find items that could differentiate our products from those of our competitors. A hint was provided by the fact that, as a glance at the market will show, on-dashboard car navigation systems retained a strong share in the market and still had the edge over AVN. Our examination determined that the predominance of on-dashboard car navigation systems is due to ① their low price, ② their large screens, and ③ the adjustability of their screens' angle. Whereas with 2DIN there is a limit of 6.5 inches on the screen size of AVN systems.

Accordingly, we focused on the consideration that a screen size of 7 inches would be possible with a housing-display type AVN system. However, housing-display systems have traditionally included a large number of protuberances, which has entailed problems such as the difficulty of designing them cohesively and securing adequate control operation space for them.

Therefore, we decided to employ two separate "faces" (appearances) for the product: a "navigation face" that is on view when the display is open and an "audio face" that is on view when it is closed. The forms of control operation would be tailored to suit each "face". In this way, it would be possible to secure the requisite size for the knobs and buttons, and to enhance operability.

In terms of overall frequency of use, AVN systems are used for audio 80% of the time, and for navigation only 20%. Under the above proposal, therefore, the display would normally be kept closed for audio use, and would be opened out only when navigation was required. This proposal resolved the problems mentioned earlier while offering an appealingly novel charm for AVN.

There remained a structural problem relating to design: at what position within 2DIN should the display be located in the closed state? The majority of opinions was that it should be located on the topmost stage of 2DIN, since that would enable the same buttons and knobs to be used both when the display is open and when it is closed, and since it would be similar to structures with a proven track record. As opposed to those merits, however, such location had the demerits that it would impair safety by limiting the driver's field of vision, and would obstruct the air conditioner's airstream outlet. The essence of the AVN product is that it houses both audio and navigation within 2DIN under a "Multi In One" concept; it is something that fits snugly into the console. Accordingly, we ultimately adopted the arrangement whereby the display is located in (opens out from) the bottommost stage.

In keeping with such thinking, we gave the screen an intuitive design, using water as motif to yield a sense of depth, and employing real icons. Coupled with the synergistic effects of the larger 7-inch display, this results in a screen that is both pleasant and intelligible.

Fig.3 Audio menu screen

The market's basic requirement is for products that anyone can view and use with ease. That is also a concept of universal design. The 9903HD product breaks free from conventional AVN structures to realize a concrete embodiment of such concept. In that sense the 9903HD, more perhaps than any other of our products, is the fruit of efforts in pursuit of universal design.

We are confident that this characteristic design will further boost ECLIPSE's presence and differentiation from its competitors in the AVN market.

3.2 Navigation functions

・Navigation engine

The present product is equipped with a new navigation engine that uses a single chip for a 64-bit BUS RISC CPU+GPS interface.

This improves basic response performance for map scrolling and map scale switching compared to former models. Specifically, it eliminates the sense of abruptness that used to occur during scrolling and scale switching, and renders such operations smooth.

Further, the new engine enables rapid route searching that is twice as fast as former models, providing easier use and extra amenity. (Refer to Table 1.)

Table 1 Route search time (Tokyo Station ⇔ Osaka Station)

	Former models	AVN9903HD
Search for 1 route	3.0 seconds	1.4 seconds
Search for 5 routes	6.2 seconds	2.8 seconds

・3D gyrocompass

The present product is equipped with 3D hybrid sensors for the first time in the ECLIPSE AVN series. Former systems were only able to sense horizontal movement of the car, but these new items permit sensing of ascent and descent motion as well. Thanks to this the system can, for example, determine whether the car is traveling on an expressway or on an ordinary road that runs parallel to it at a lower level. Such capability achieves higher accuracy for map matching. (Refer to Fig. 4.)

The product is further equipped with multistory/underground parking lot map functions that utilize the 3D hybrid sensors and parking lot data stored in the map data. These functions indicate information such as parking lot entrances/exits and the location of the user's car inside a lot, thus eliminating bother and worry for users. (Refer to Fig. 5.)

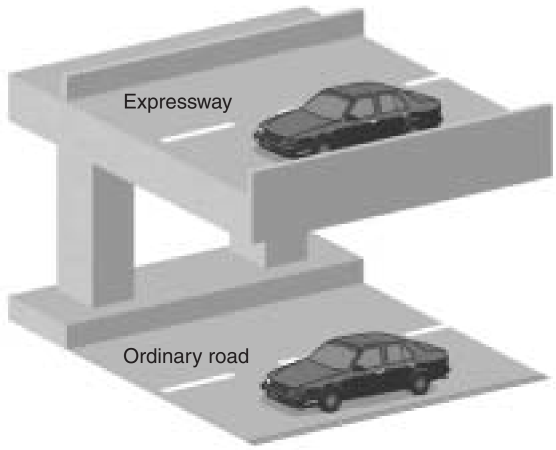


Fig.4 Effects of 3D hybrid sensor

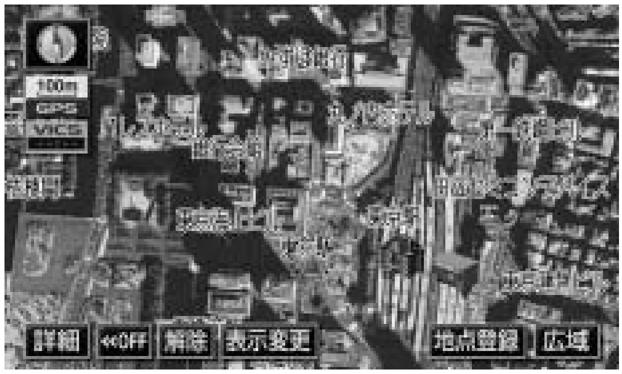
Fig.5 Multistory/underground parking lot map functions

・IKONOS zoom

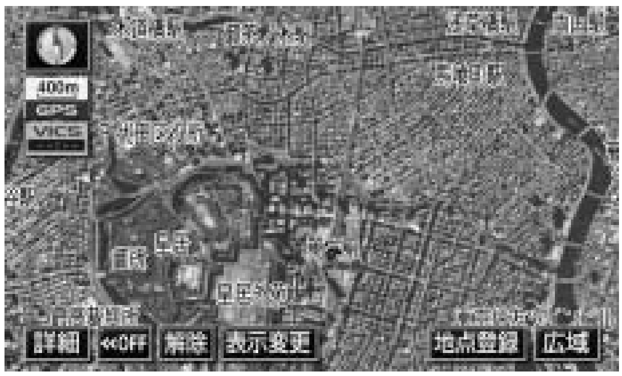
Navigation functions that utilize IKONOS satellite imagery*2 have been realized in our AVN products from the Autumn 2002 model onward. The new product adds 2 new functions to enhance the level of the satellite shots.

The first of these functions provides continuous switching of the map scale between 50m and a maximum of 800m, whereas earlier models offered only a 2-stage 50m⇔100m scale switch. This enables map operation with the same feel as using an ordinary map, as well as providing situational details over a much-enlarged area of the car's surroundings. (Refer to Fig. 6.)

The second new function provides indications of the names of landmarks - something that has not appeared in satellite images hitherto. Such indications enable at-a-glance identification of buildings, providing reference points on the way to one's destination, and enabling more accurate pinpointing of one's own location. This means added appeal for the product as regards practical usefulness and convenience. (Refer to Fig. 6.)



IKONOS satellite image 100m of scales



IKONOS satellite image 400m of scales

Fig.6 IKONOS satellite image continuous zoom and landmark name indications

3.3 7-inch display

In former product forms there was an upper limit of 6.5 inches on the size of the display because of constraints imposed by the 2DIN size. Since the display could not be made larger using the same product form, we adopted a different, housing-display form that permits a 7-inch display. This larger size enhances the visibility of maps, DVD videos and TV pictures. (Refer to Fig. 7.)

(＊2) IKONOS is the world's first global observation satellite for commercial purposes. It was launched from Vandenberg Air Force Base in the U.S.A. in September 1999 and can capture high-quality images of any place on the Earth's surface with a resolution of 1m.

Fig.7 7-inch display

3.4 LCD (liquid crystal display)

The present product employs a "dual face" concept involving an "audio face" and a "navigation face". The product has the audio face when the display is closed. An LCD that is familiar from equipment with integrated audio is employed as the display for the audio face. Such LCD provides a 5 × 7 dot matrix, 10-digit display and the indicator for the source and play modes. (Refer to Fig. 8.)

Fig.8 LCD display

3.5 Constant reception of FM-VICS

Former AVN equipment was only able to receive FM-VICS when the audio source was in the FM mode. The present product is able to receive FM-VICS outside of the FM mode, thanks to the employment of a TV tuner that can receive signals right up to the FM band.

4 System configuration

Fig. 9 shows the differences between the present product's system configuration and that of its parent, the Autumn 2002 model AVN9902HD.

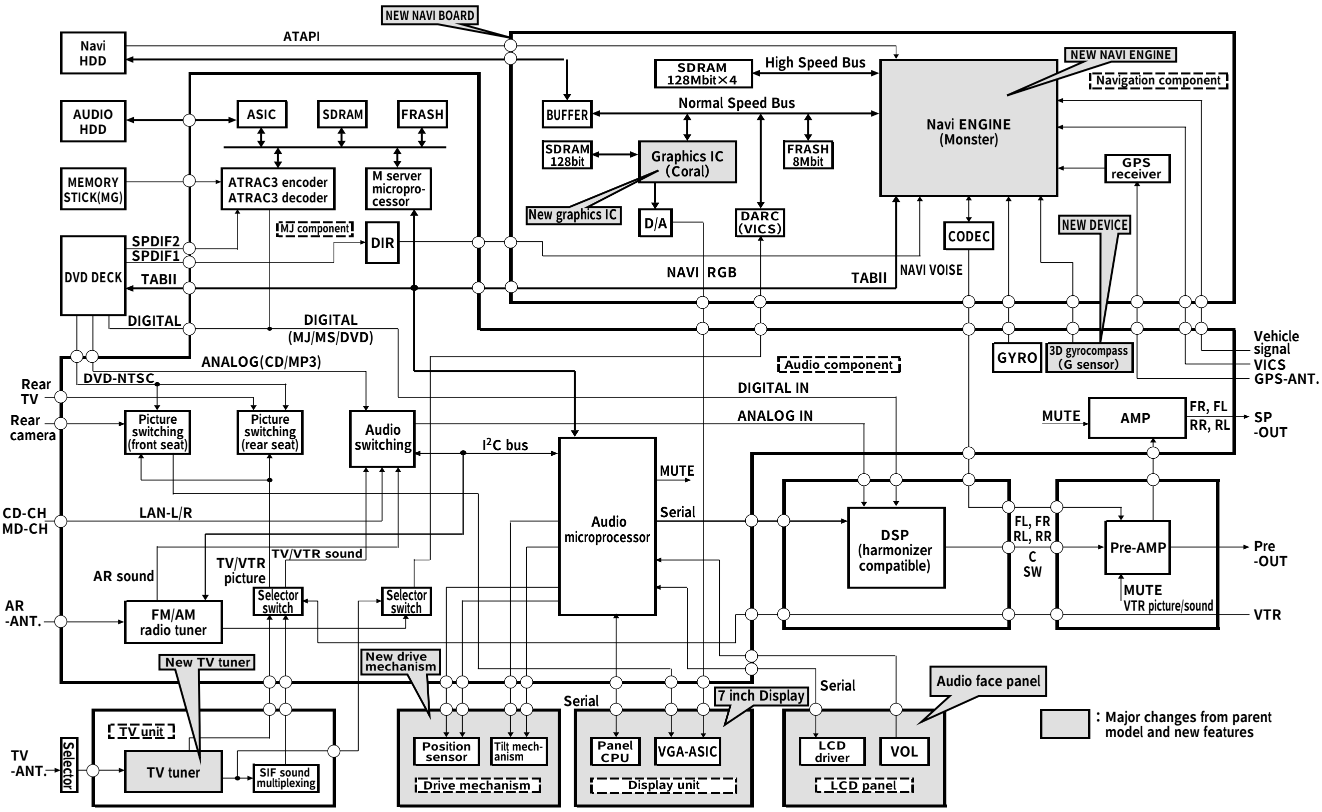


Fig.9 System diagram

5 Technology development items

5.1 ASIC with built-in CPU core + graphics engine

In order to introduce top-level products into the car navigation market, where capabilities and performances are continually advancing and prices becoming steadily lower, we have to constantly develop car navigation platforms of the very highest levels. That employed in the present product is the strongest platform developed for 2003 model car navigation. Its backbone hardware consists of a "Monster" (development code-word for an ASIC with built-in CPU core) and a FUJITSU-made graphics LSI (referred to by its popular name Coral).

The ASIC with built-in CPU core (Monster), which is responsible for the internal computation processing for car navigation, has the 3 major features described below.

Firstly, the CPU core consists of 2 built-in CPUs - a main CPU and an I/O CPU. The internal processing for car navigation can be considered as divided into two kinds: processing that is based on internal data for searching, retrieval, guidance and map displays, etc.; and processing that is based on external data such as input from sensors for tracking the car's current location. Though these two types of processing must constantly be implemented in parallel, they arise non-synchronously. Furthermore the characteristics of the latter type are affected by external factors. For these reasons, employing a single CPU to perform all of the processing will entail interactions between the 2 processing types that will cause overhead, resulting in a fall in processing efficiency. As a means of avoiding such problem the new product employs 2 CPUs so as to have each type of processing performed separately.

Secondly, the operating frequency of the main CPU has been improved. This is a commonly employed means of raising performance, in for example computers, but is difficult to apply to car navigation systems and other in-vehicle equipment because of their severe operating environments. Accordingly, the operating frequency of 236MHz that has been realized in the present product may be said to be the world's highest level in the field of car navigation.

Thirdly, the CPU external data bus has been enlarged. The processing for car navigation consists of computation processing inside the CPU (CPU-internal processing), plus accessing of devices (such as memories and I/O devices) that are exterior to the CPU (CPU external accessing). Second feature above (increased operating frequency) is a sufficient means of improving the performance of CPU-internal processing. But something additional is required to improve the performance of the CPU external accessing in equipment that continuously handles large amounts of data, of which a car navigation system is a typical example. A highly effective means to such end is to enlarge the volume of data that can be handled at one time - in other words to expand the CPU external data bus. The present product's car navigation platform secures a 64-bit bus width that enables its performance to drastically exceed those of former platforms.

So far our discussion has mainly concerned improvement of the computation processing capacity for car navigation. But we also achieved improvements in the performance and representational power of the screen display (graphic-user interface, GUI), which can be said without exaggeration to be the most important item in a car navigation system. The indispensable element for such improvements is the graphics engine "Coral".

Coral is different from a conventional graphics accelerator. Brought into being through collaboration between development teams from an LSI manufacturer (FUJITSU) and a car navigation manufacturer (FUJITSU-TEN), it is so to speak a graphics engine for car navigation, providing particularly high performance for graphics functions that are specific to car navigation (α blending, antialiasing, bold line graphics, multilayer management, etc.)

By realizing a wide variety of graphics processing, Coral has enabled visually-impacting and beautiful GUI displays that impose no stress on the user.

There is no room for doubt that this Monster and Coral device pair is the backbone of the strongest platform.

5.2 3D gyrocompass

One of the most important factors in car navigation performance is the present position accuracy. Conventionally, tracking of the present position has been realized via 2D map matching that utilizes GPS (Global Positioning System) data, 2D gyrosensor data, vehicle signal (speed and reverse signal) information and road shape data. The present position data obtained in this way is data for position in a plane(coordinates), and recognition of roads that cannot be expressed solely via coordinates in a plane, such as elevated roads, has had to rely on map matching (the calculation of present position coordinates from the travel path and the road shape).

But, with the 3D gyrocompass employed in the present product, it is now possible to determine the travel path in the vertical direction. Together with the addition of altitude data to the map data whenever necessary, this makes possible the 3D map matching that was beyond the reach of former systems. The result is drastically improved present position accuracy, particularly on elevated roads.

And using similar methods another function is able to provide users with data locating their present position within certain types of multistory and underground parking lots.

5.3 Space-saving measures

5.3.1 Structure

With the present product the display panel component has to be housed inside the main body when it is closed.

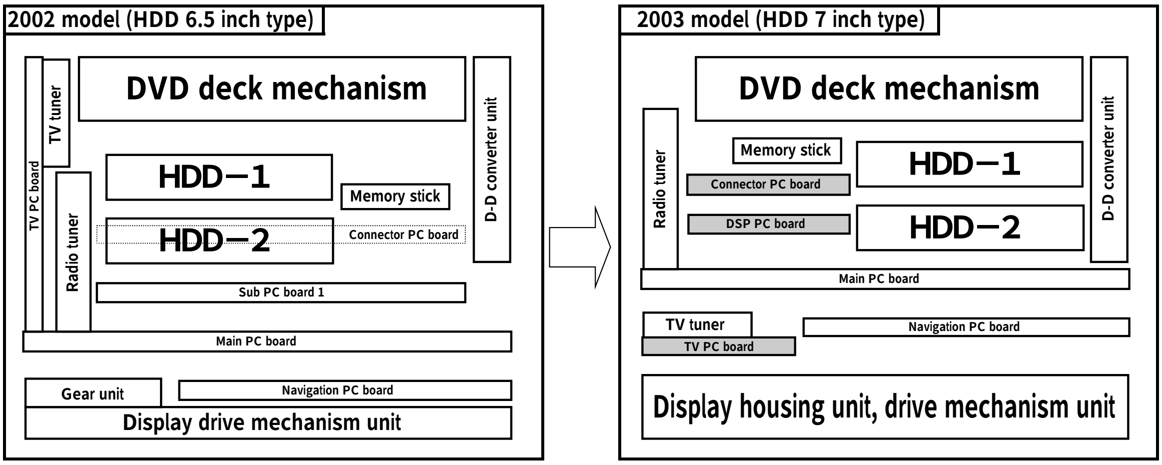


Fig.10 Structural comparison of Autumn 2002 model and present product

To that end, the display panel component had to be made thinner and the interior parts of the main body had to be concentrated together to a much greater degree than previously so as to create the requisite space.

Therefore, we revised the structural layout of the interior parts from scratch, and rigorously eliminated all waste of space. As a result, it was possible to house all of the components, excepting the display panel, in a space that amounted to 83% of that previously used - practically a 1.5DIN space (height 75 mm). In the interest of reliability, however, we took care that use of the navigation board and DC-DC converter - both key parts - can be shared. (Refer to Fig. 10.)

However, such reduction of the spacing between the components caused a reduction of the exhaust pathways for the heat generated by the interior parts. This had the adverse effect of lowering the heat exhaust efficiency.

The following are the main measures that were taken to counter rises in the interior parts' temperatures:

①A thermo fluid analysis using computer aid engineering (CAE) was utilized to select optimum fans and determine the optimum locations in which to deploy them.

②Air intake pathways through the front panel were secured.

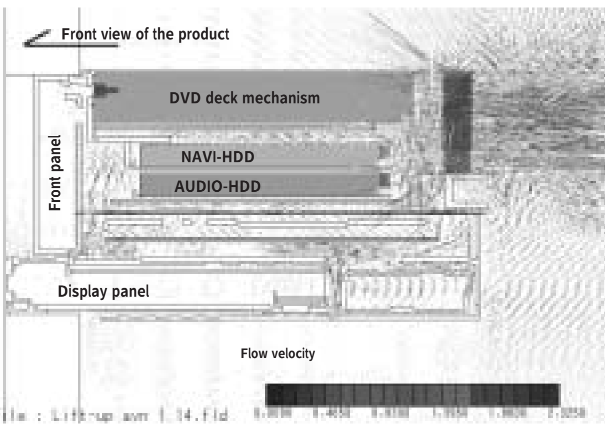


Fig.11 Thermo-fluid analysis in CAE

③The heat buildup sources were identified using a thermotracer. (Refer to Fig. 12.)

④Concentrated heat dissipation measures (installation of thermal-conductive sheets and dedicated heat sinks) were taken for the heat buildup sources.

The implementation of these measures successfully resolved the problem.

5.3.2 Circuit board configuration

As mentioned above, the present product differs from its parent model AVN 9902HD in that it houses its display inside the main body (when the display is closed), and this feature made it necessary to achieve a circuit board configuration that could fit within a 1.5DIN size. To that end,

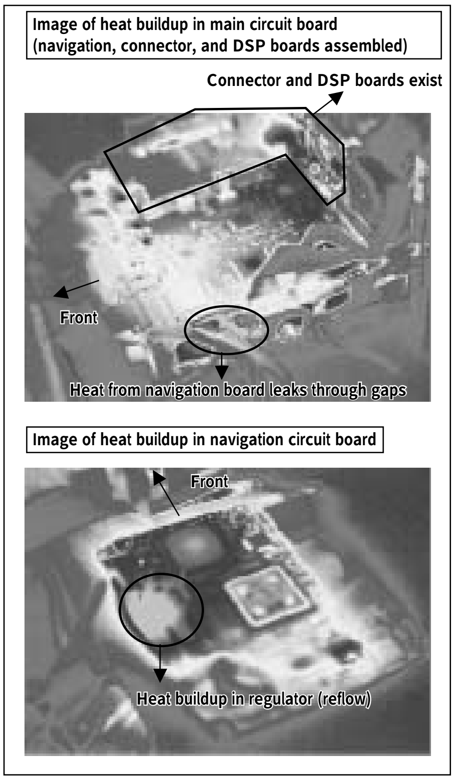


Fig.12 Identification of heat buildup locations via thermo-tracer

we divided the circuits up into blocks allowed for interfaces between the circuit boards, and revised the board configuration.

First of all, since the former music juke (MJ) circuit board could not be utilized for structural reasons, we decided to move all the MJ circuits to the main circuit board. The TV circuit board from former models could not be used within the 1.5DIN size space, so instead we deployed it in the vacated portion where the drive mechanism was located in the former models. As a result the TV circuit board was now located beside the car navigation circuit boards, entailing a reduction in its size. Accordingly, we moved some of its circuits to the main circuit board.

With consideration for the organization of the parts layout on the main circuit board, by moving the MJ circuits and reducing the size of the TV circuit board, we were able to move the audio circuits (including the DSP circuits), some of the power supply parts, and the pre-out output I/F to the connector and DSP circuit boards. By so doing we were able to achieve a circuit board configuration that was compatible with the 1.5DIN size. (Refer to Fig. 13.)

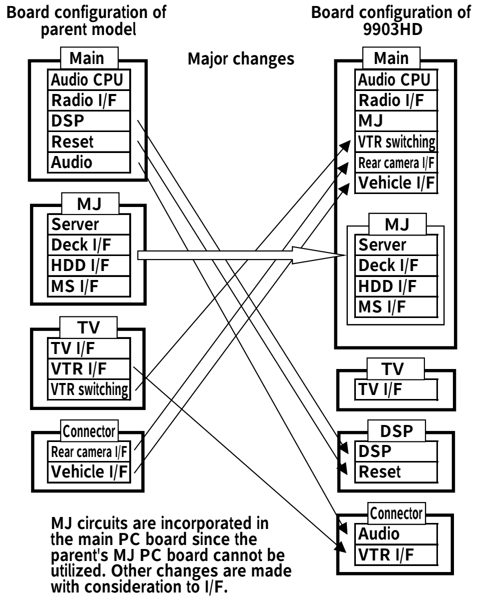


Fig.13 Differences in circuit board configurations

5.4 Drive mechanism

For the present product it was necessary to develop a new drive mechanism that could enable a display panel unit comprised of a 7-inch VGA LCD, touch panel functions and front control unit etc., to be slid closed, opened out, and tilted.

To that end, the design gave consideration to making the drive mechanism itself compact, securing space for the sliding parts in the width direction, and securing the requisite rigidity for touch panel and button operation.

The noteworthy aspects of the mechanism component can be listed as the following:

①Anti-jolt springs installed in the direction of tilt-up, to eliminate any feeling of joltiness when the display panel is operated.

②The depth dimension is kept within 165 mm in the interest of installability to the vehicle. Additionally, a 2-stage tray structure is employed to curb protuberances of the front portions.

③Employment of a compatible structure that provides interchangeability with other 1DIN type models (for the North American market), whereby the drive mechanism can be installed in either the upper or the lower portion in the main body.

④As compensation for the weight increase in the display panel component, sintered metal gearwheels plus electroless nickel plating are employed for the drive gears, thereby securing rigidity and reducing the load that occurs during drive.


Fig.14 Drive mechanisms

5.5 LCD panel

5.5.1 Software (control)

1) Control configuration

Control of the LCD panel is performed by a navigation microprocessor and an audio microprocessor. The allotment of roles between these two is as follows:

- The navigation microprocessor uses data for TFT display to create data for LCD display, and notifies the audio microprocessor.
- The audio microprocessor controls the LCD controller and displays the data sent from the navigation microprocessor.

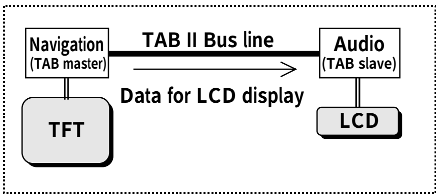


Fig.15 Communication control

2) Display control

- In display control, the display area is divided into an indicator and a text area. These are controlled by two TAB II commands corresponding to each portion.

・Additionally, the text area is configured with a virtual layer structure so as to realize superimposition control.

A diagram of the display control configuration is provided below.

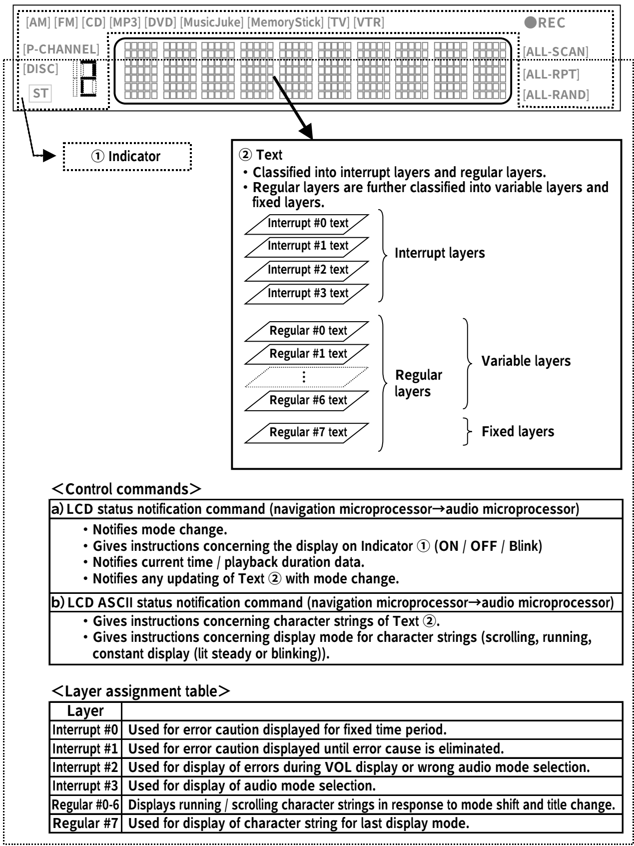


Fig.16 Control configuration diagram

The text area is capable of using alphanumeric characters, katakana syllabary or symbols for its character strings, but in order to minimize the communication load, a particular code is prescribed for it. This is the "ESC code", and it is able to specify the status to be maintained by the audio. microprocessor.

・This results in text displays enable to track items - such as broadcasting frequency during radio AUTO.P operation - that have short update times.

The figure below illustrates the processing flow.

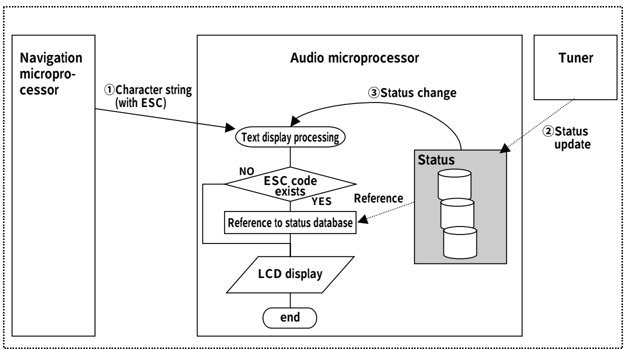


Fig.17 Processing flow chart

3) Simulator

・This is the first time that an LCD has been used in AVN. Accordingly, in order to secure design quality and with the additional purpose of achieving early awareness and verification of the communication specifications together with our collaborating manufacturers, we developed an LCD simulator that could simulate the LCD's operation on a PC for verification.

・This simulator is able to implement an LCD display in response to any communication command file (written in any manner desired) . The simulator was made available to our product planning department and to our collaborating manufacturers in order to verify the LCD operation. The results of their verifications, which were common for concerned parties, were incorporated into the communication specifications. In this way we were able to prevent any troubles that might have resulted from imperfect awareness or conflicting understandings of the LCD.

The figure below provides a general view of the simulator.

Fig.18 Simulator screen

5.5.2 Removable panel structure (accommodating HDD replacement)

With HDD car navigation systems, HDD replacement (for the purpose of updating map data) has to be performed while the system is installed in the vehicle.

Former AVN systems are provided with an HDD opening and cover on the side of the main body panel that is opposite to the display panel, permitting replacement of the HDD while the display is open. But with the present model, that kind of space is not available, so instead we opted for a structure that permits the entire audio operation panel to be removed.

Employing such structure assures adequate design space when the "audio face" is on view, and permits a larger LCD display and large-size buttons and knobs. Thus, such structure provides visually-impacting design combined with realization of higher visibility and ease of use.

Furthermore, the panel mounting bolts are provided with features that will prevent them from falling out from the audio operation panel and being lost when the panel is removed.

Fig.19 Removable panel

5.6 FM-receiving TV tuner

The following circuits were added to the currently-used TV tuner to render it able to receive the FM band:

①circuits for FM trap-through during FM reception;
②RF-AGC circuits for FM;
③circuits for turning IF-AGC off during FM reception.

Moreover, to accompany the FM-VICS receiving TV tuner, we have newly added a film antenna that can receive the FM band.

6 Conclusion

Above we have described the development of a new type of integrated AVN with a twofold, "dual-face" appearance. We were made keenly aware that success in development such as this requires a strong will for accomplishment that is not shackled by the existing conceptual framework.

The success was also due to our pursuing a series of innovations lacking in our competitors - such as introduction of a built-in TV tuner and of triple decks (DVD/DC/MD) - that have driven the constant evolution of our company's AVN.

The AVN form of equipment has now become naturalized in the world of car navigation. More and more competitors are entering the AVN field and many different variations on the product have emerged.

We wish to close this paper by declaring our company's intention to go on pioneering new AVN products that match market needs and offer our customers delight, surprise and immense satisfaction (CS and CD).

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"MAGIC GATE" Sony Corporation
"MUSIC Juke" FUJITSU TEN LIMITED
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