Development of Aftermarket AVN with Built-in Digital Terrestrial TV Tuners for Autumn '07 in Japan

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Abstract

The transition from conventional analog to digital terrestrial television (hereinafter referred to as DTT) broadcasting is being promoted to be completed in July 2011. Accordingly, DTT receivers have dramatically become widespread as home-use television sets. The demand for DTT tuner units as an in-car product has been growing year after year and they have increasingly become common in vehicle, as seen in the tie-in sales with a car navigation device.

FUJITSU TEN has developed an AVN with built-in DTT tuners having even a B-CAS card slot and commercialized it as an aftermarket AVN (AVN687HD) for autumn '07. This paper explains its functions and features.

1 Introduction

The digital terrestrial TV (hereinafter referred to as DTT) broadcasting began in 2003 and DTT tuners have become dramatically widespread as home-use television sets. The demand for DTT tuners as an in-car product has been growing year after year. In the car AV industry, manufacturers have developed DTT tuner units and sold them as a tie-in with a car navigation device. As a result, the tuners in vehicle have increasingly become common.

FUJITSU TEN has released products compatible with the DTT broadcasting in a timely manner, such as a separate tuner unit that is connectable to an AVN and an AVN with built-in One-Seg receiver. This time, we have developed a further advanced AVN (AVN687HD) with built-in DTT tuners that can receive One-Seg and 12-segment broadcasts.

This is the first AVN in the industry that adopts the four-tuner method and provides even a slot for a B-CAS card, which is required to descramble the DTT broadcasts. This AVN embodies our technical advantage, "All in One", following our 1DIN AVN and AVN with built-in One-Seg receiver.

In addition, we will discuss here the newly developed AVN including its improved screen focusing on "easy-to-operate" to watch DTT.

2 Product Outline

Fig.1 AVN687HD

It has been common to install a DTT tuner unit separately from a car navigation unit. However, small cars and certain other types of cars have difficulty finding the space for a separate DTT tuner unit, and we received many requests for AVN with built-in DTT tuners, which drove us to develop this model.

Integration of DTT tuners and a B-CAS card slot in AVN unit eliminated the interconnecting wire harness required before. That brings huge advantages with respect to neat and tidy appearance and reduced man-hours for installation.

For this AVN, we have adopted the four-tuner method instead of the conventional two-tuner method. With optional rear antennas, the four tuners can receive signals from four antennas respectively and synthesize the signal data by calculating the optimal data synthesis ratio. The optimal data synthesis realizes stable reception even under the circumstances of poor signal reception such as Doppler shift caused by positional relation of a car with a broadcasting antenna and multi-path where the airwaves reflected on buildings are mixed with original airwaves. Thus it expands the DTT reception area.

3 Improvement of Operability

We have improved the user interface for operational screens of this model to enhance "easy operation". **Fig. 2** shows the example of new screen and **Fig. 3** shows the previous one. In this section, we will show main specific changes.

Fig.2 Operation Screen of DTT (Previous)

Fig.3 Operation Screen of DTT (New)

①Display method of channel numbers

Conventional AVNs display a physical channel number (equivalent to a UHF channel number) that depends on the airwave frequency. However, as it is not familiar to the users in most places, they do not know which broadcaster it represents before they tune and watch the screen actually. This AVN shows a channel number from one to twelve in the same way as a home TV remote control does. At the same time, it also shows a three-digit service channel number that is peculiar to the DTT broadcasting.

②Channel selecting buttons

Conventionally, we have used the method that an AVN allocates receivable broadcasters to eight buttons. With this method, however, it is difficult for users to smoothly choose a desired broadcaster because they have to search its channel number whenever choosing the broadcaster, and in addition the button is displayed with physical channel number. After we discussed what would be the best way to display a channel number, we decided to use the same way as the TV remote control at home. By arraying the buttons from one to twelve in four rows three lines and showing a small image of a program beside those buttons like a home-use TV screen, our users can select a desired channel smoothly watching TV program.

③Selection of buttons arranged on operational screen

We chose and arranged on the menu screen the function buttons that are considered to be frequently used such as the "program" button to skip to the EPG (Electronic Program Guide) screen, a peculiar function to DTT broadcasts, the "data" button to show detailed information of the program such as its cast and plot, and the "channel" button to display the selected channel number and other buttons. With those buttons, users can operate this AVN with fewer steps.

④Channel setting

We added the guide function to set channels for initial setup. This new AVN automatically searches receivable broadcasters and allocates them to the channels from one to twelve. When a user uses the AVN for the first time, it displays a guide message advising to set channels. Therefore, even beginners can easily complete the setting without owner's manual and then enjoy DTT programs immediately.

4 Electric Circuit Design

4.1 Conventional Separate DTT Tuner Unit

We could not integrate the separate DTT tuner unit currently sold by FUJITSU TEN LIMITED into an AVN without any modification due to its shape and heat resistance. We had to miniaturize parts and reduce power consumption.

Fig. 4 shows the diagram of our separate DTT tuner unit. In the F/E (Front End), we have adopted a diversity system with four antennas and two tuners, which controls switching four antennas and combines the airwaves received by two tuners at maximum rate with an OFDM demodulator IC. The PCB size of the F/E is about 264cm^2.

In the B/E (Back End), a CPU controls an AV decoder IC to decode video / audio signal. The decoded video is sent and processed in a drawing ASIC where GUI designs are created. Its PCB size is about 176cm^2. The total power consumption of F/E and B/E is about 19W.

After calculating the dimensions and power consumption in the light of its mechanism structure in order to fit those parts into an AVN, we set targets: the F/E PCB to be 200cm^2 (about 76% of our conventional one) or less, the B/E PCB to be 120cm^2 (about 68%) or less and power consumption to be 14W (5W reduction or about 74% of our conventional one). The following section explains how we achieved those targets.

4.2 Efforts to Have Tuner Built In

Fig. 5 shows the diagram of the DTT portion of this AVN with the built-in tuners and the details are explained below.

4.2.1 Miniaturization of F/E

We took the two approaches mentioned below to miniaturization of the F/E.

1) Miniaturization of receiving circuit portion

2) Integration of tuner control CPU into B/E CPU (an integrated CPU)

We faced a problem when miniaturizing the receiving circuit as the first approach because we needed to change the diversity system from two to four tuners for better reception as mentioned in the section of Product Outline. Usually, an increase in tuners from two to four requires about double of space. Contrarily, we needed to make the size smaller for miniaturization. Therefore, we began to review the entire circuit structure. First of all, we adopted silicon tuners, which do not require tuned circuits using coils or SAW filters, to save the space. We also adopted an OFDM demodulator IC for four diversity tuners. In addition, we modularized the receiving circuit portion (from tuners to the OFDM demodulator) as a package. With these efforts, we were successful in miniaturization.

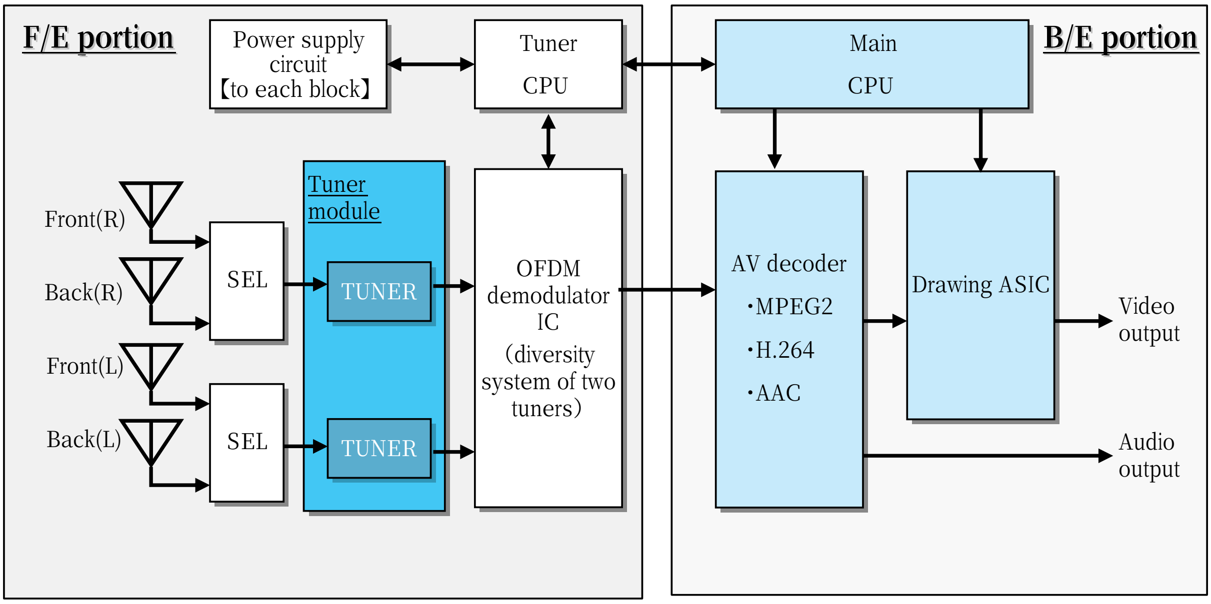


Fig.4 Separate DTT Unit Structure

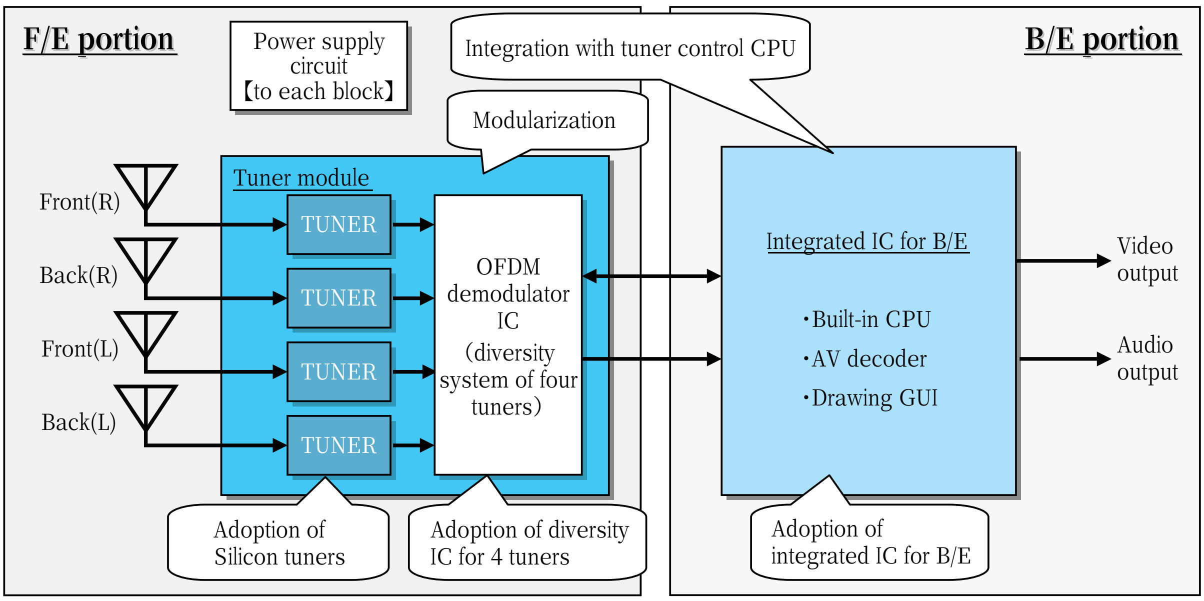


Fig.5 DTT Portion Structure of Aftermarket AVN for Autumn '07

Moreover, in order to integrate CPUs as the second approach, we achieved control of the F/E portion by the CPU on the B/E portion by adopting a high-speed processing CPU, which is elaborated in the next section.

With these improvements, we attained the targets to reduce the F/E PCB size to 185cm^2 (about 70% of our conventional one) from 264cm^2.

4.2.2 Miniaturization of B/E

We made drastic changes in the system to miniaturize the B/E portion. The conventional B/E consisted of three ICs of CPU, AV decoder IC and drawing ASIC. Instead of those individual ICs, we adopted a one-chip IC integrating these three to save space. However, we faced another challenge by adopting the one-chip IC: high-speed processing capacity. We needed to use DDRII-SDRAM memory and design a system using fast frequency of 600MHz level, which FUJITSU TEN LIMITED had not produced before. In order to realize the high speed processing, we simulated and analyzed the impedance and crosstalk of the circuit board at the design phase and then decided the pattern layout. We conducted impedance control of the completed PCB by preparing impedance check pattern and ensured the board satisfying all target values. We examined waveform patterns obtained in actual measurement at the trial phase and confirmed that the impedance including its variation would not cause any problem when the miniaturized B/E is installed in a vehicle. As a result, this high-speed processing was materialized successfully (**Fig. 6**).

By making those changes, we reduced the PCB size of the B/E portion from 176cm^2 to 110cm^2 (63% of our conventional one) and achieved the goal.

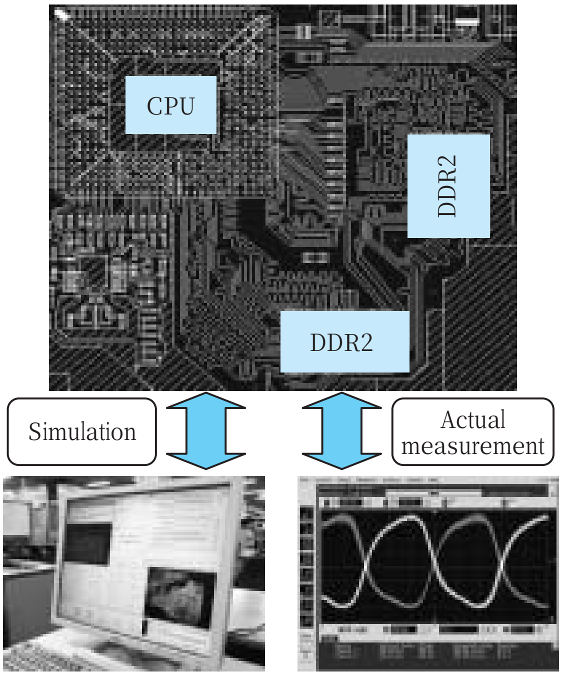


Fig.6 Challenge to High-Speed Processing

4.2.3 Reduction of power consumption

The miniaturization (including the integration into one-chip IC) mentioned so far contributed to the reduction of power consumption to 11W (58% of our conventional one) from 19W as we aimed.

5 Mechanism Design

Fig. 7 shows the structure diagram of this AVN.

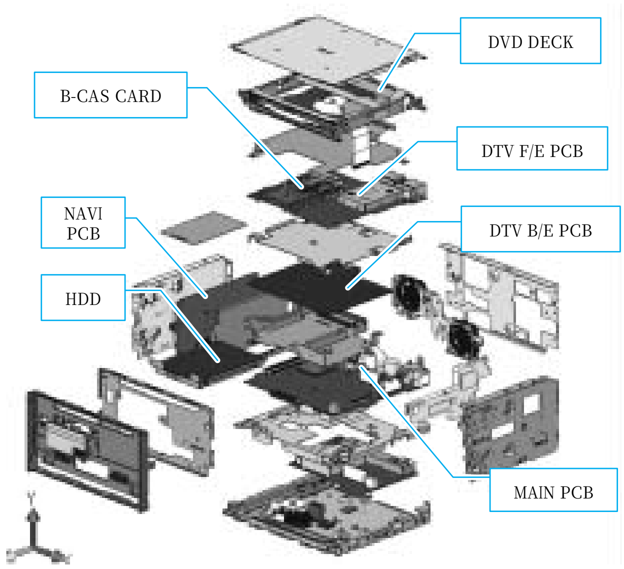


Fig.7 Product Structure (Exploded View)

5.1 Design for Small Space

Another challenge to an AVN with built-in DTT tuners was to make space for a B-CAS card slot and DTT circuit boards. The new AVN is designed based on our aftermarket AVN for autumn 2006 and we needed to find the additional space with the thickness of 17mm for the slot and the boards within it.

We created space for the DTT portion (two PCBs) and shield sheets by adopting a thin DVD deck and integrating MJ (Music Juke) PCB and the main PCB into a single PCB.

- DVD deck thinner than the one for autumn '06 −7mm
- Integration of the PCBs −10mm

TOTAL : −17mm

5.2 Design for Heat Dissipation

This AVN requires a good heat dissipating capability because internal temperature of conventional AVNs possibly surpasses the temperature that a B-CAS card can withstand. Moreover, additional DTT circuits increase the internal temperature further.

In order to lower the internal temperature, we utilized thermo-fluid analysis from the planning phase to examine an optimal layout of heating parts and heat dissipating parts (fans and heat sinks).

1) Laying out a B-CAS card slot away from heating parts
2) Placing fans just behind the heating parts and the B-CAS card for good ventilation and heat dissipation (**Fig. 8** and **Fig. 9**)
3) Using heat sinks for heating parts such as navigation IC and audio power IC and placing them at the outermost of the AVN for better heat dissipation (**Fig. 10**)

4) Making holes in the guide portion for the B-CAS card to improve its heat dissipation

Those improvements lowered the internal temperature and allowed B-CAS card to be built in.

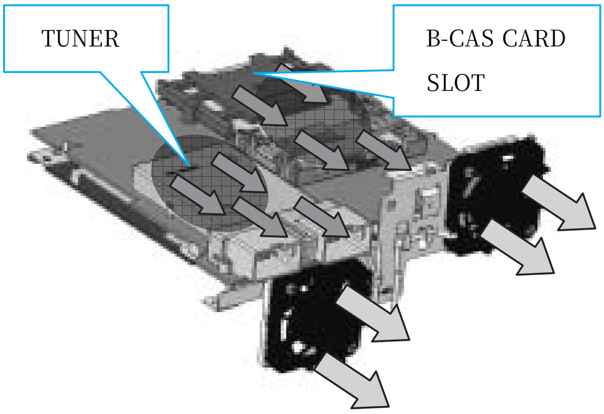


Fig.8 Heat Dissipation Design for DTT PCB (F/E Portion)

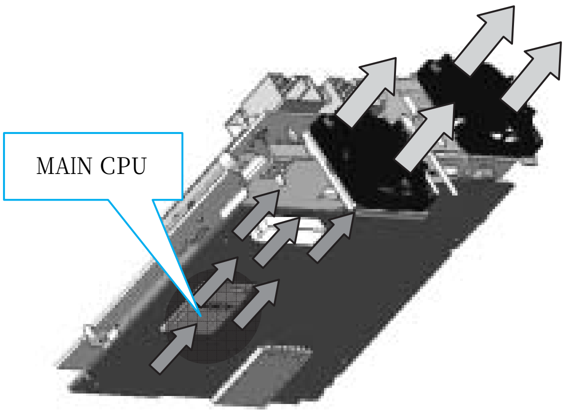


Fig.9 Heat Dissipation Design for DTT PCB (B/E Portion)

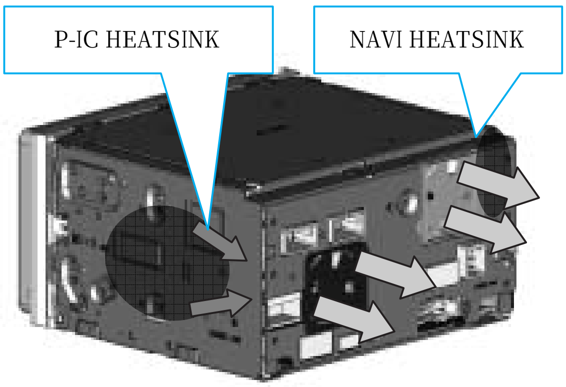


Fig.10 Design for Heat Dissipation (Portions other than DTT)

5.3 EMC and Low-Cost Structure Good for Assembling Work

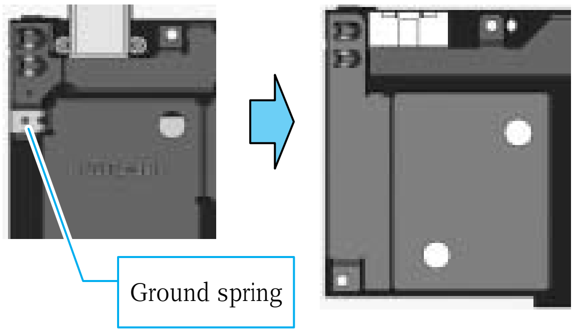
This AVN is designed based on our aftermarket AVN for autumn 2006 (with built-in One-Seg tuner) in which navigation PCBs are arranged lengthwise along a side, shield sheets are placed between PCBs to reduce noise, and circuit boards and sub-modules are piled orderly from the bottom for good assemblability. In addition, we successfully cut cost by reducing the number of parts and simplifying shapes of some parts.

1) Reducing or eliminating a ground-connecting spring and parts for EMC improvement (Example 1)

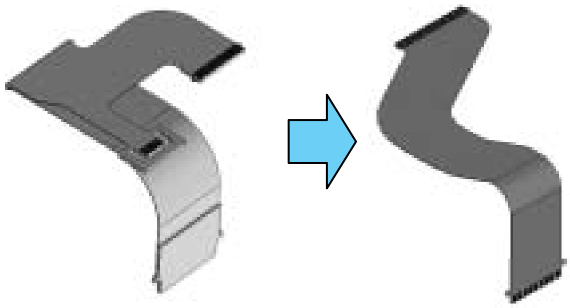
2) Simplifying shapes of parts (Example 2)

3) Developing an operating portion of B-CAS card in-house (Example 3 and Example 4)

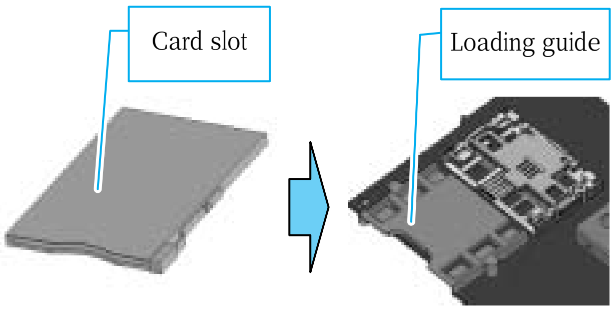
Example 1: elimination of a ground-connecting spring by integrating parts



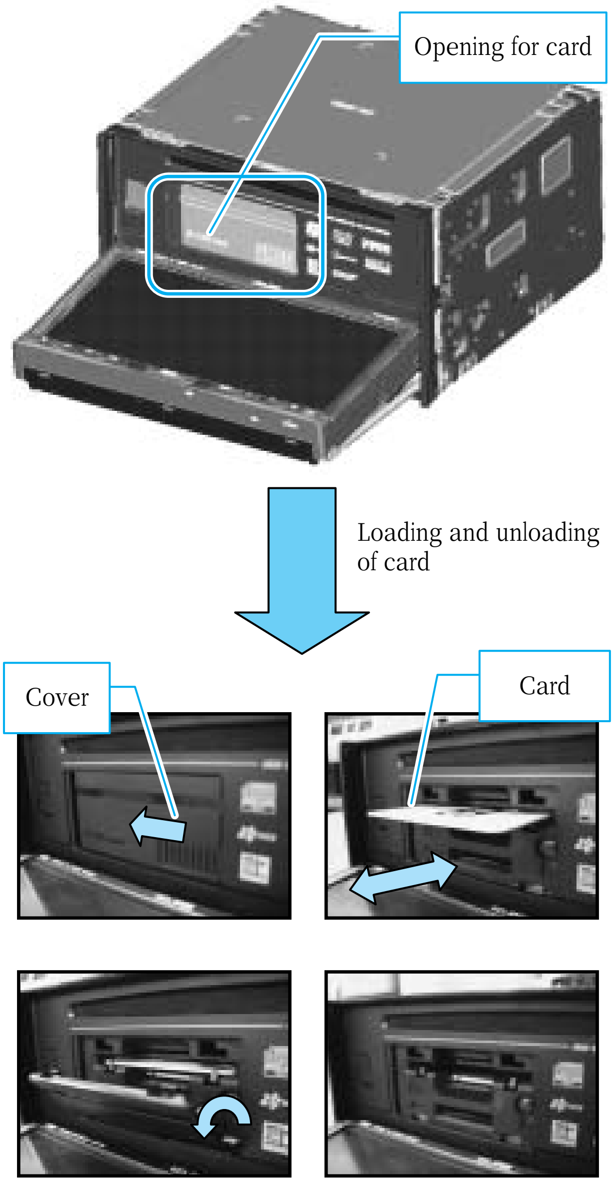
Example 2: simplified parts (flexible cable)



Example 3: cutting the card slot cost by half by in-house designing of the loading guide for the card slot. Examined structure to be good in vibration endurance of their contacts and heat dissipation in consideration of in-vehicle installation.



Example 4: we placed the opening for B-CAS card on the front panel of the internal device and add its cover from aesthetic aspect. When the cover is removed, it is unlocked and opened in sliding method, held by the panel portion to prevent it from falling on the display panel and then it is removed. The card is loaded into the slot and locked with the projections of the internal card loading guide. In this way, we created the reliable card-operating portion at low cost.



6 Summary

The following points describe our achievements of this development.

①Easier operation

- **Same button arrangement as a remote control of a home TV set**
- **Display of the three-digit service channel number**
- **Display of the frequent-use buttons on the menu screen**

This AVN is much easier-to-operate for users because our improvements made it similar to their familiar remote control for home TV sets.

②AVN with built-in DTT tuners due to miniaturization

- **Miniaturization of F/E portion (about 70% compared to our conventional one)**
- **Miniaturization of B/E portion (about 63% compared to our conventional one)**
- **Smaller space by adopting a slim DVD deck and an integrated PCB (17mm thinner than our conventional one)**

Installation process was remarkably simplified by incorporating a B-CAS card slot in the AVN.

③Improved reception performance

The diversity system with four antennas expands the receivable area to 1.4 times of our conventional products.

This AVN has a wide variety of functions besides the above-mentioned, so we would like to introduce some briefly.

One of the standard functions of this AVN is KEITAI-Link, a function newly introduced for summer 2007, and other new functions meet market needs along with conventional ones.

One good example of those functions is: compatible with playback of DVD-VR with which DTT programs can be recorded. Besides watching those programs in real time, the function allows users to watch recorded programs in the vehicle. As a navigation device, this AVN is compatible with smart IC display (smart exits or smart InterChanges in Japanese), which have been introduced across Japan. In order to enhance drivers' confidence and safety, this AVN displays guiding lines for moving backward on the image taken by the backside camera.

7 Conclusion

We have explained the purpose and functions of our aftermarket AVN for autumn 2007 with built-in digital terrestrial tuners.

The tuners and a B-CAS card slot are integrated in an AVN so that installation process has become dramatically simplified. By renewing user interface to make it "easy-to-operate," we achieved an AVN with which users can easily enjoy DTT broadcasts free from stress of difficult operation or confusion.

We hope we will continue to develop easy-to-use products that can give a pleasant surprise and delight to users, utilizing our advantage, "All in One" technology.

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