Development of AVN with the One-Seg Service Reception Function for Autumn 2006 Model for the Japan Market

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Abstract

The terrestrial TV broadcasting service in Japan has undergone a transition to digital broadcasting, and the transition is scheduled to complete in July 2011. The One-Seg service, a category of the terrestrial digital TV broadcasting service, which is for mobile devices, began in April 2006. Compared to the 12-segment broadcasting, the One-Seg service has wider coverage as well as stable images and sound due to digital technology.

We developed AVN (AVN7406HD) incorporating a function of receiving the One-Seg service for our autumn 2006 model. This paper elaborates its function and characteristics.

1 Introduction

TV broadcasting is one of the media services familiar to us at home. People very much want to enjoy this entertainment in cars too. To meet the demand, the function for receiving TV broadcasting is equipped in AVN (an integrated product of Audio, Visual, and Navigation in 2DIN), which FUJITSU TEN introduced for the first time in the industry.

The shift of the Japan's terrestrial TV broadcasting to digital broadcasting was decided to promote as a government project, and the transition should be completed in July 2011. The digital broadcasting by ISDB-T (Integrated Service Digital Broadcasting-Terrestrial) began in December 2003. Initially, the digital broadcasting service was provided only for the home entertainment purpose (13-segment broadcasting), including high definition TV broadcasting, and then the One-Seg service for mobile devices started in April 2006 using one of the 13 segments.

Due to the application of the 4-channel antenna and our original diversity technology, we have sold external receivers since 2005 that can stably receive terrestrial digital TV broadcasts for home entertainment.

With the start of the One-Seg service, focusing on its stable reception in a wide area, we developed the AVN (AVN7406HD) incorporating the One-Seg service receiving function.

On this occasion, we renovated the display designs, interfaces to users. The new design will be shown in this paper.

2 Outline of new product

Outline of AVN7406HD, autumn 2006 model, is listed below.

Common specs.

Exterior dimension: 2DIN (W180×H100×D165)
Weight: Approx. 3.2kg
mounted deck: DVD/CD compatible deck
HDD 40GB (for both audio and navigation systems)
Operation method: Front touch panel display and buttons on the panel

Display

7-inch wide EGA display
Screen size: W156×H83 (mm)
Pixel count: 336,960 (480H×234V×3 elementary colors)

AV portion

・One-Seg service (13 to 62 channels/stereo and multiple broadcasting)
・Analog TV (1 to 62 channels/stereo and multiple broadcasting)
・Radio (AM/FM/FM multiple broadcasting)
・CD (CD-R/-RW capable)
・DVD video playback
・MP3/WMA playback
・MJ (Music Juke, recordable up to 3,000 songs)
・Automatic titling (auto titling function) by CDDB and automatic music download (FM de TITLE) from CDDB.
・Video playback on the rear seat display

3 Design

3.1 Background of design development

A 7-inch screen has been popular in the market since 2005. But the big screen costs operability (with smaller-sized buttons and others).

There were evaluations that while the diversified functions of AVN make operation more complicated, operation buttons are smaller and the operability is poorer. That is a result of efforts to satisfy the request of the big (7- inch) screen. Naturally, the market of the car navigation system that becomes more multi-functional and complicated looks for better operability.

When looking at a conventional model (Fig. 1), buttons are located both vertically and horizontally, and the number of buttons on the panel is as much as 14 buttons. At a glance, it seems difficult to operate. New users are often confused about which button is the start button, and take some time to call up information that they want. However, we found that the panel buttons were well rated by some users. As the new users are accustomed to the panel buttons, they are found to be convenient because they allow users to skip at once to the information that they need. The evaluations led us to a conclusion: A product that has both "easy-to-follow operation" for new users and "shortcut operation" for experienced users will meet the market demand. We launched development of a new easy-to-follow operation system, focusing on the keyword "a model whose layout is user-intuitive and sophisticated, and that achieves user-friendliness by GUI (Graphical User Interface) on the touch panel display."

Fig.1 Menu Screen of Conventional Model

3.2 Approach to a new operation

In order to achieve both of "user-friendly looking (good first impression) and practically easy operation", we reviewed the number of buttons on the panel and overall layout in pursuit of user-friendly operation with which users will never be confused. The goal was met by the three following changes.

①Rearrangement and reduction of buttons

We reduced the number of buttons on panel from 14 to 9 after studying when and how often users use the buttons.

While we decided to retain the buttons for "Current Location", "Volume" and several others that are often used in driving, we integrated 4 menu buttons of "Navigation", "Audio Source", "Information" and "Destination Directory", which users need to look at the screen to operate for detail setting, into one "Menu" button as an integrated start menu.

②Design of top menu screen

Taking the following points into account, we re-designed the top menu screen to make it seem easy to operate.

a) Color-coding/layout: clarify function categories
b) Colorful: prevent users from being unwilling to operate
c) High brightness and chroma saturation: make it seem user-friendly
d) Bigger screen buttons: make them easy to touch
e) Coloring per subject: use related colors per subject across hierarchies

Fig 2 shows the top menu screen.

Fig. 3 shows the design of respective menu screens.

③Layout of panel button

Being distinguishable in the center, "MENU" button, a start button for operation, leads users to further operation.

Since the AVN may be sold globally in the future, we took operability overseas into account. Thus, panel buttons are laid in a row just below the display, which allow both drivers and passengers to reach them easily.

Fig.2 Top Menu Screen of Autumn 2006 Model

Fig.3 Respective Menu Screens of Autumn 2006 Model

4 One-Seg service reception function

4.1 What's the One-Seg service?

The One-Seg service is the terrestrial digital broadcasting service for mobile receivers, including mobile phones, in Japan. The One-Seg service uses only one of the terrestrial digital broadcasting segments. The following summarizes the One-Seg service.

In the ISDB-T method, about a 5.6MHz transmission bandwidth is divided into 13 frequency bandwidths (about 429kHz each) to transmit. The divided frequency bandwidth unit is called segment. In a segment, there are sometimes layers in which broadcasting information is grouped by content, purpose, or others. The number of the layers is limited to as many as three in the ISDB-T method. Out of transmission parameters, modulation, convolutional code rate, and time interleave can be set in respective layers.

The One-Seg service consists of one segment with one layer, and One-Seg service receivers can receive only the One-Seg service out of 13 segments. The segment of the One-Seg service is always positioned in No. 0 (in any broadcasting channel).

Fig. 4 shows the segment position (screened) of the One-Seg service.

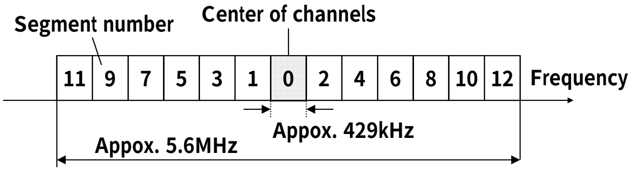

Fig.4 Layout of Segments in Broadcasting Bandwidth

4.2 Characteristics of the One-Seg service

Since receivers with insensitive antennas, such as mobile phones, are presumed to use, parameters (double interleave time and QPSK modulation) different from the 12-segment broadcasting are adopted. Thanks to them, those receivers cope with instantaneous interruption better and receive broadcasts with less electricity than the 12-segment broadcasting.

However, in exchange for high durability to interruption, its maximum transmission volume is so small that frame rate, which represents video resolution and smoothness, falls below one for the 12-segment broadcasting because the One-Seg service employs a video coding method with a high compression rate (H.264/AVC).

The comparison of parameters between the current One-Seg and 12-segment broadcasting is shown in Table 1.

Fig. 5 indicates the relationship between electric field strength and reception quality of the analog, 12-segment, and One-Seg service.

a, b and c show the values of electric field strength that each type of the broadcasting requires to gain practical sensitivity. For example, if electric field strength is below the point of C ($60dB\mu v/m$) in the analog broadcasting, noise appears on screen and it makes it difficult to watch.

The receiver for the One-Seg service can work all right even when its electric field strength is weaker than the one of the conventional TV broadcasting. That is the reason why our new reception system is equipped with a single antenna. (As for its structure, please refer to the section 6.)

Table 1 Comparison of Transmission Parameters Between One- and 12-Segment Broadcasting

Item \ Type	Layer A Transmission of One-Seg	Layer B Transmission of 12- segment
Modulation	QPSK	64QAM
Convolutional code rate	2/3	3/4
Time interleave (ms) ＊1	430	215
Minimum C/N (dB) ＊2	6.6	20.1
Maximum transmission capacity (Mbps)	0.416	16.851
Video coding	H.264/AVC	MPEG-2
Video resolution rate ＊3 (horizontal×vertical pixel)	320×180 320×240	720×480 640×480
Aspect ratio	16:9 or 4:3	16:9 or 4:3
Frame rate (Frame /Sec)	15	Approx. 30
Audio coding	MPEG-2 AAC	MPEG-2 AAC
Audio channel	1 / 2 (stereo)	1 / 2 / 5.1

＊1: Time necessary for randomizing the transmission order on the broadcasting side.
＊2: C/N (Carrier to Noise Ratio)
＊3: Parameters of SD (Standard Definition) 480I is used for the ones of the 12-segment broadcasting as examples.

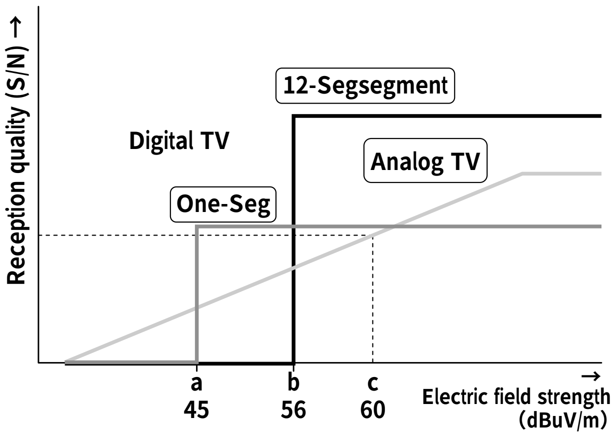

Fig.5 Comparison of Electric Field Strength Required for Respective Broadcasting (Calculated Value)

4.3 Reception circuit for the One-Seg service

Fig. 6 shows the block diagram of our developed reception circuit for the One-Seg service.

When receiving only the One-Seg service out of the terrestrial digital TV broadcasts, the front-end tuner IC only needs reception bandwidth for one segment. Since the transfer bit rate is lower, an OFDM (Orthogonal Frequency Division Multiplex) demodulation IC and source decoder on the back-end circuit board of a One-Seg receiver can be smaller than the ones of a receiver for 13-segment broadcasting. That means it is possible to create a configuration for small-sized circuits.

As for the front-end board tuning into electric waves and taking out demodulated digital data, intermediate frequency is set at as low as 571kHz. The board is comprised of a coil tuning circuit, silicon tuner (1-chip IC) that does not use a SAW (Surface Acoustic Wave) filter, and OFDM demodulation IC exclusive for the One-Seg service.

The silicon tuner is well-suited to being equipped in cars because of its adjustability to shakes and its easy miniaturization.

We designed the back-end board that decodes images and audio data from demodulated data streams, using TMS320DM320A, a digital media processor of TEXAS INSTRUMENTS Incorporated, as its core.

The TMS320DM320A incorporates high-functional DSP, ARM (＊1) processor, video encoder including OSD (On Screen Display). It executes the following operations by itself.

①Decode H.264/AVC and MPEG-2 AAC
②Expand images
③Control the tuner
④Interface with the host microprocessor

4.4 Decoding

The decoding process by DSP+ARM is described in Fig. 7 and the process is summarized below.

The decoding process of images and audio starts with buffering TS (Transport Stream) input from the tuner. And then, the TS is broken down at TS DEMUX (DE-multiplexing) into PESs (Packetized Elementary Streams), image/audio data, to be decoded respectively. Since image PESs are time-division-multiplexed with audio PESs, images should be synchronized with audio on the receiving side. The controller for playback timing synchronizes images with audio using PCR (Program Clock Reference) and PTS (Presentation Time Stamp) that describe time data in the TS.

By a newly developed algorithm that corrects errors appropriately, we achieved reduction in screen block noise that occurs due to weak electric waves or reception troubles

(＊1) ARM: Advanced RISC Machine

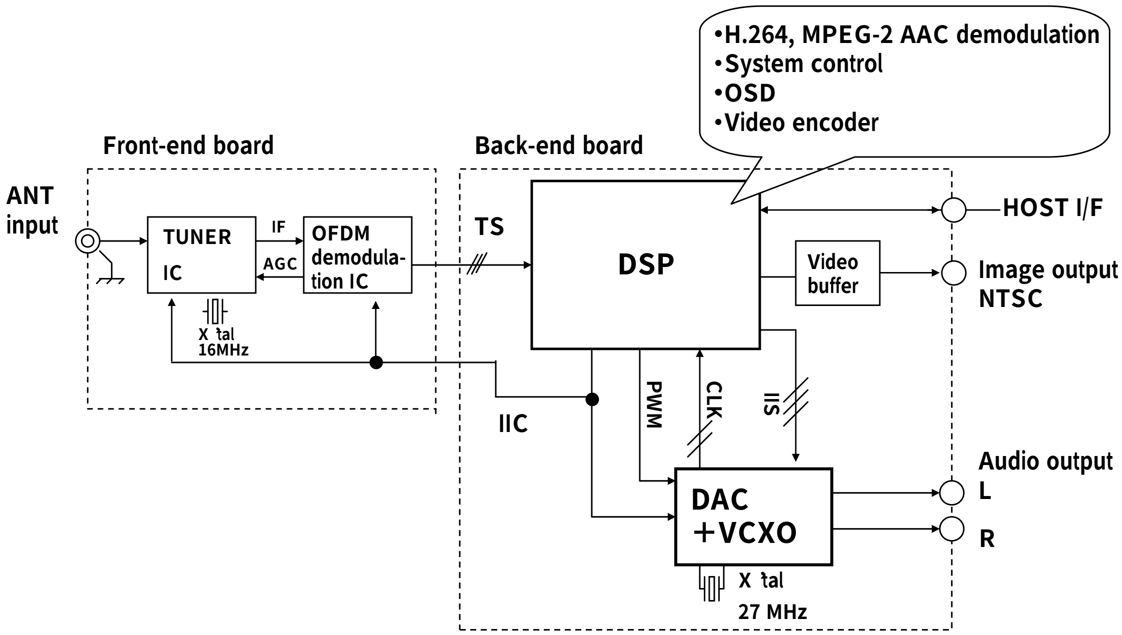

Fig.6 Block Diagram of One-Seg Service Reception Circuit

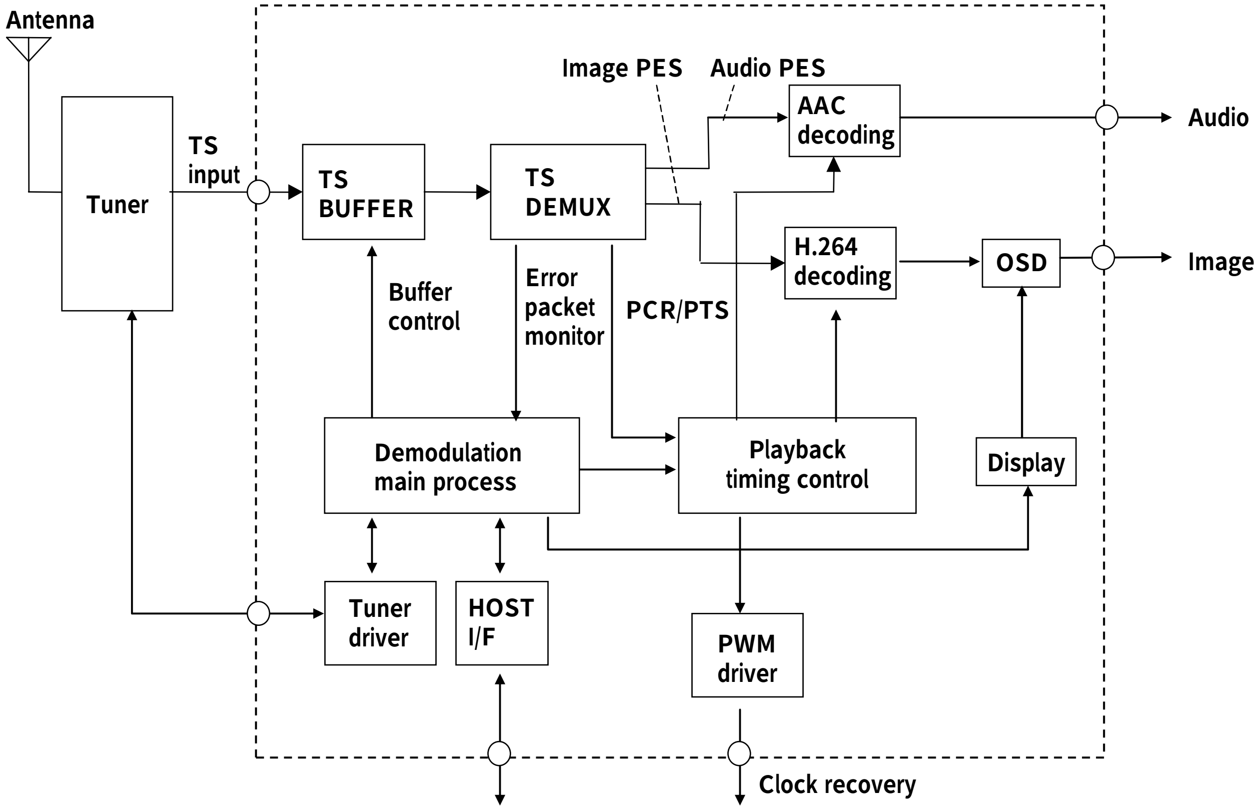

Fig.7 Block Diagram of Demodulation Processing

5 Structure Design

Easy assembly as well as noise interference between circuits and/or units requires attention in structure design.

In order to achieve easy assembly, our autumn 2006 model has a structure where circuit boards and sub-modules are piled orderly from the bottom and the circuit boards are connected directly to other boards by "board to board" type connecters shown in Fig 8.

We arranged an analog tuner (AM/FM/TV) at the bottom, furthest from digital processing circuits (for navigation, HDD, MJ, etc), noise sources, and we place shield sheets between boards for the purpose of reducing the possible influence of noise. We shield the One-Seg reception circuit that contains both an analog and digital circuits to make it a package because it is sandwiched between the DVD deck circuit and HDD.

6 Reception antenna

For receiving the One-Seg service, we have just developed a film antenna that combines GPS, analog TV and One-Seg antenna elements. The new antenna allows us to keep the same (2-piece) structure as the conventional antenna even when adding the function for receiving the One-Seg service to a conventional antenna.

The structure of our new antenna is shown in Fig. 9.

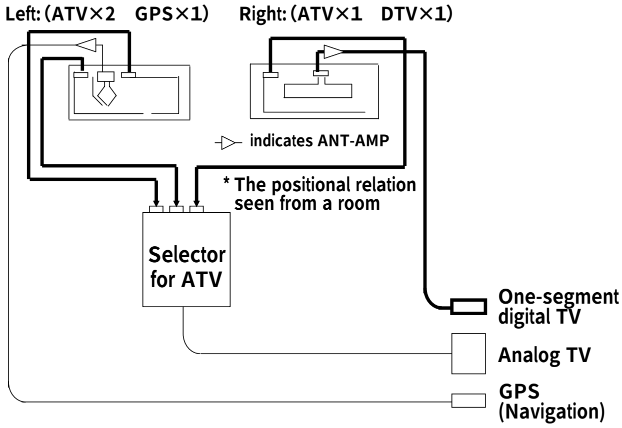

Fig.9 Circuitry of Complex Antenna for One-Seg, ATV, and GPS.

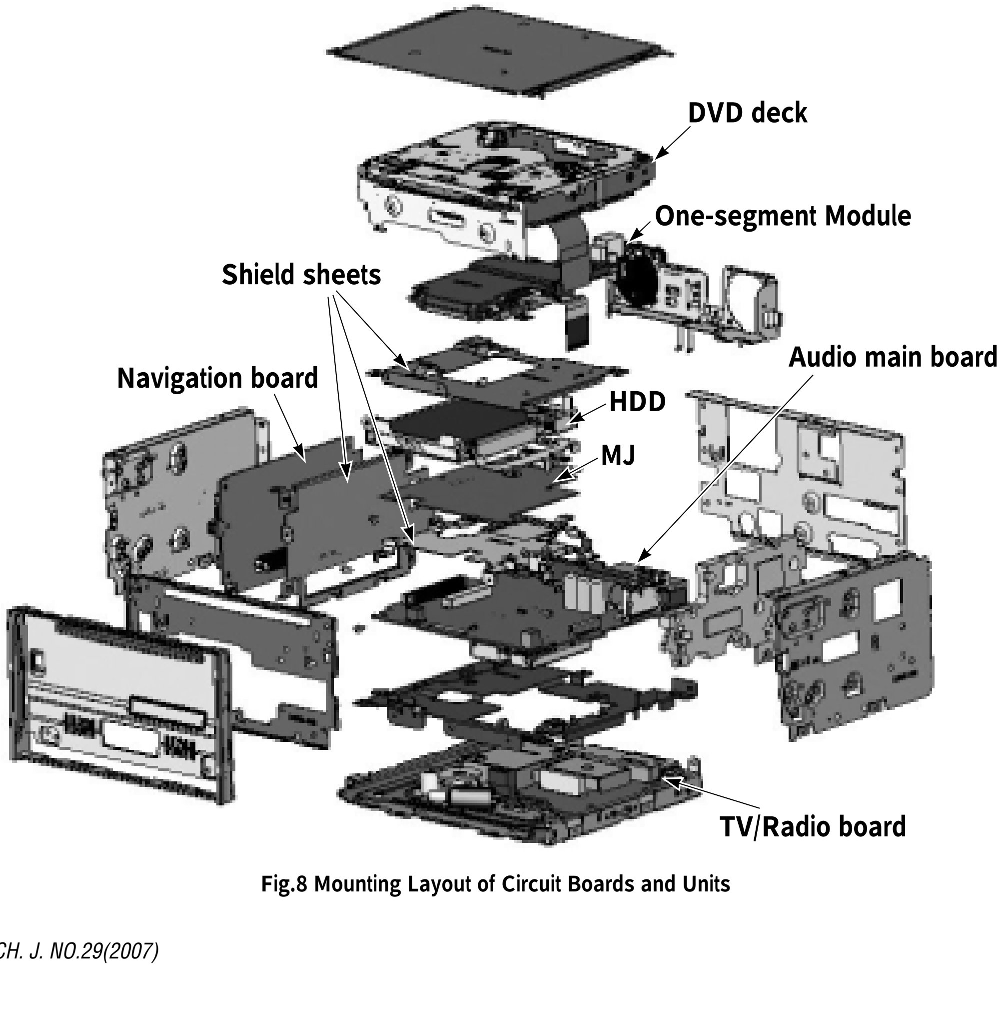

Fig.8 Mounting Layout of Circuit Boards and Units

7 Conclusion

This paper has explained the development aims and characteristics of our autumn 2006 model into which we incorporated the One-Seg receiving function and the new screen design.

We hope the embedded function for receiving the One-Seg service and the adoption of our new original antenna help customers enjoy digital broadcasts easily. At the same time we are proud of our efforts to make the AVN user-friendly, not difficult nor complicated to operate, while making it multifunctional.

We, as a pioneer of AVN, would like to do our best effort in continuously achieving good functions and high performance,

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