Development of AVN for 2008 Summer Model for Japan Market

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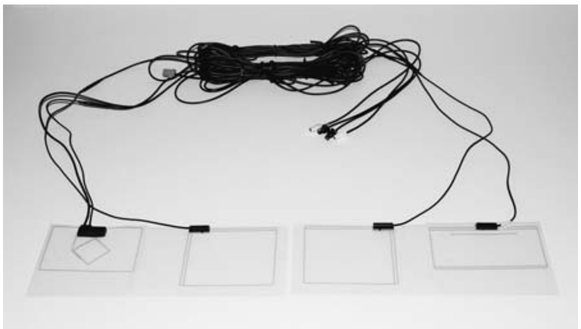

Abstract

For ground-based TV broadcasting, the infrastructure development for full transition to digital broadcasting in July 2011 is well advanced. Likewise for the car navigation business, the transition from analog to digital has been progressing since 2005.

In our 2008 model, we improved the receiving performance and picture quality, and developed our AVN that includes the function of terrestrial digital broadcasting. We introduce its functions and features in this article.

1 Introduction

The terrestrial digital TV broadcasting which began in 2003 enables the viewer to receive higher-quality picture than conventional analog broadcasting and delivers not only picture and sound but also diverse information such as information linked to the programor community-based information as data broadcast. For these convenience reasons, terrestrial digital TV broadcasting has become widespread as home television according as the service area has expanded. On the other hand, the car navigation system is normally equipped with the analog television to meet the needs that the users want to enjoy watching TV in a car. However, it had weak point that the picture/sound is often distorted due to the unstable reception caused because the car is moving from place to place. From 2005, each manufacturer released tuners for terrestrial digital broadcasting for vehicle installation, focusing on the terrestrial digital broadcasting as revolutionary technology to solve that weak point of the conventional analog television, with the dissemination of the terrestrial digital broadcasting for home television and expansion of service area for the terrestrial digital broadcasting.

The price transition in the Japanese car navigation market (categorized by product) is shown in **Fig. 1**.

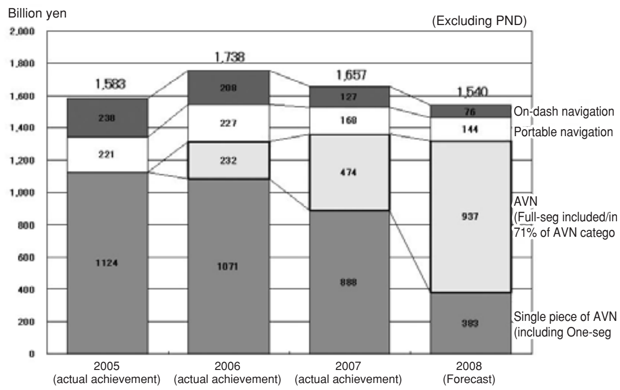

Fig.1 Price Transition in Japanese Car Navigation Market (categorized by product)

In 2006, the car navigation system compatible with terrestrial digital broadcasting spread rapidly because of such factors as the major price decline of tuners for terrestrial digital broadcasting, and the release of products packaging the car navigation system and tuners for terrestrial digital broadcasting. In 2008, the car navigation system which is responding to the terrestrial digital broadcasting is predicted to become mainstream, equipping the tuner for terrestrial digital broadcasting instead of the tuner for analog broadcasting.

FUJITSU TEN also focused on making AVN, our leading product, compliant with terrestrial digital broadcasting. As the first step of engineering development, we tackled incorporation in the AVN. We released an AVN with One-seg tuner in autumn 2006, and released an AVN with the tuner for terrestrial digital broadcasting in autumn 2007. We predict that the function to receive the terrestrial digital broadcasting will be a standard feature from 2008, and as a next step, we tackled the improvement of the reception performance/picture quality performance, mounting of antenna, and operability of car navigation system in order to differentiate ourselves from competitors. As a result, we achieved the introduction of "picture digital transmission", "antenna responding to front 4ch variable matching system", and "seamless switching between the terrestrial digital broadcasting and One-seg broadcasting." We introduce the new technology related to the terrestrial digital broadcasting in this article.

2 Digital Transmission of Picture

2.1 Aim of Development

The higher-quality picture of liquid crystal is an important element for users when they purchase a mobile device such as mobile phone, game machine, and others, as well as the car navigation system that is our market. Therefore, we need to improve not only the conventional map display but also the picture quality of terrestrial digital broadcasting that has been increasing in recent years.

The picture had been transmitted by analog signal from navigation drawing to image processing section in front of the liquid crystal, so a fine blur of characters and colors occurred due to the error caused by the signal conversion between analog and digital. Therefore, for the digital transfer of picture, we introduced Low voltage differential signaling (hereinafter referred to as LVDS) that has good transmission performance and less radiation noise, in order to remove the misalignment between the navigation drawing and picture shown on the liquid crystal display, and to realize the high- quality picture.

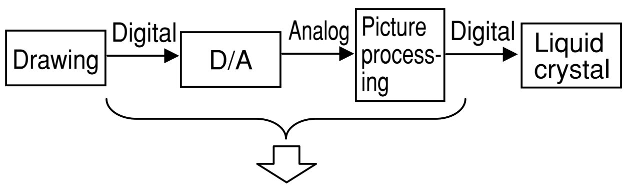

Fig.2 Improvement of Picture Quality by Digitalizing Analog and Transmitting through LVDS

2.2 LVDS as Digital Transmission of Picture

LVDS is prescribed by TIA/EIA-644 but for the multipurpose utilization, only its electrical characteristic of transmission and reception is prescribed. Therefore there are no regulations on the connector, cable, transmission protocol, etc. and we are able to design to meet applications. We can design freely but need to select the parts suitable for the vehicle installation. Advantages are as follows:

- **Low electromagnetic radiation**
- **High exogenous noise resistance**
- **Easier wiring and terminal than parallel connection**

LVDS has low radiation and yet has high signal-to-noise ratio so we can get high-speed data rate. In addition, the power consumption is lowered because this signal is small. LVDS is a differential signaling system so it has high exogenous noise resistance by common mode noise rejection and enables the high-speed transmission. Therefore the amount of wiring can be reduced by seriating the data.

The picture transfer LVDS installed this time is shown in **Fig. 3**.

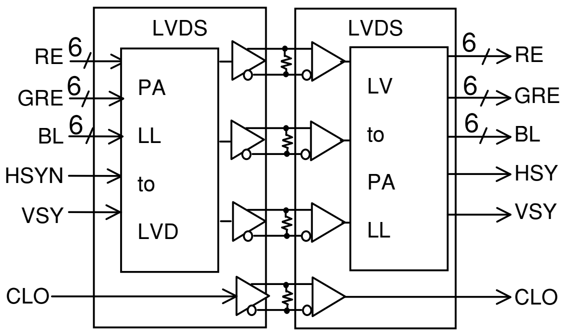

Fig.3 Implemented Picture Transfer LVDS

The picture data (RGB18bit, HSYNC, VSYNC) is converted to 3 differential pairs of 7bit-length data by LVDS TX (transmission) IC. The clock signal is converted to the differential signaling separately. LVDS RX (reception) IC receives the signal of 100Ω termination resistance and restores the image data.

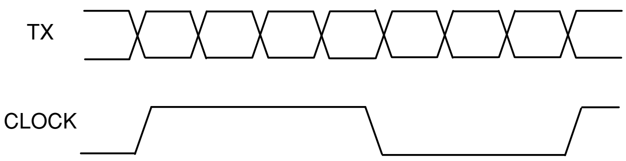

Fig.4 7bit Length of Data is Synchronized with Clock and Transferred

2.3 Challenges for Vehicle Installation

An AVN must have low radiation noise so as not to cause adverse effect on its radio, terrestrial digital broadcasting receiver, and other in-vehicle devices. We therefore conducted the following:

(1) Low-amplitude

We changed the amplitude of LVDS signal, standard amplitude to low amplitude. Relative to the approximately ±100mV of threshold voltage for the receivable voltage width of receiving side, the output voltage of the transmitting side is approximately 250 to 400mV. Therefore we aimed to lower radiation noise, lowering the amplitude of the transmitting side to approximately 200mV.

Table 1 Main Electrical Specification of LVDS

Trans-mission	Offset voltage	Approx. 1.25V
	Output voltage	Approx. 250 to 400mV
	Output voltage when low amplitude	Approx. 120 to 300mV
Recep-tion	Range of input voltage	0 to 2.4V
	Threshold	Approx. ±100mV

(2) Path impedance

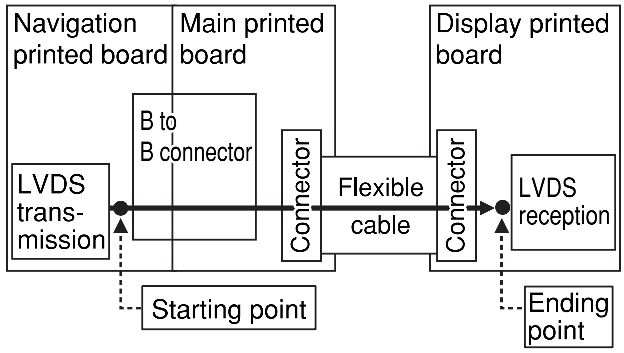

Fig.5 LVDS Path

LVDS is mounted in a position shown in **Fig. 5**. If the impedance of the whole path is not uniform with the value close to 100Ω, transmitting performance will deteriorate, and the radiation noise will increase due to the common mode noise. Therefore we designed the printed board, connector, and flexible printed board in the path so that their impedance become approximately 100Ω.

2.4 Verification

(1) Verification of low amplitude

①Error rate

As for the deterioration of transmissibility considered as side-effects of the low amplitude, we conducted the error rate measurement to confirm that there is no data error before and after transmitting/receiving, specifying the number of data to be transmitted, and then we confirmed that there was no error.

②Eye pattern

Eye pattern refers to the waveform overlapping the LVDS differential signal (plus and minus) by the differential probe. The larger the eye pattern opens, the better the signal quality is. We confirmed the waveform of the eye pattern aperture is opening enough.

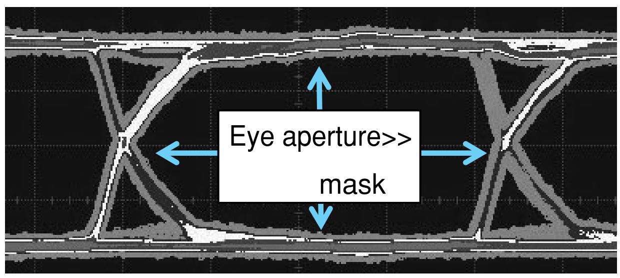

Fig.6 LVDS Eye Pattern

(2) Verification of path impedance

We measured the path impedance by TDR measurement for the whole path and confirmed that the impedance was closed to 100Ω shown in **Fig. 7**. We conducted the design consideration of pattern width and others so that the impedance of each printed board become close to 100Ω.

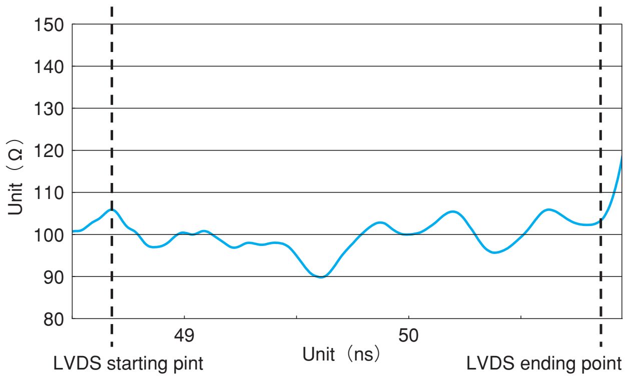

Fig.7 Example of TDR Measurement Result

We also simulated the change of eye pattern waveform relative to the dispersion of impedance of the printed board, connector and flexible printed board and conducted the confirmation with the worst conditions.

As a result, we enabled the higher-quality picture display with less blur of characters or colors, realizing the digital transmission of pictures by LVDS.

3 Variable Matching System for Terrestrial Digital Broadcasting

3.1 Operating Principle of Variable Matching System

"Matching" used here means the matching status of impedance between antenna and amplifier set directly beneath the antenna. The better the matching, the less the loss. And as the matching deteriorates, the loss becomes larger and the sensitivity becomes worse.

The operating principle is shown in **Fig. 8**. "Head unit" is a chassis including the receiver of the terrestrial digital broadcasting, such as AVN. "Pickup unit" is a unit including the amplifier directly installed on the antenna feeder that is put on the automobile windshield, shown in **Fig. 9**.

In the conventional fixed-matching system, as shown in the upper line in **Fig. 8**, the impedance of antenna varies significantly depending on the frequency so the loss of some decibels arises at a frequency where the matching deteriorates.

Therefore, instead of the conventional "fixed-matching," we set the "variable matching" where the varicap diode (variable-capacitance diode), which is the impedance change element, is placed as shown in the lower line in **Fig. 8**.

We developed the structure to switch the parameter of the matching status as shown in the lower line in **Fig. 8**. To keep the better matching, we enabled the improvement of sensitivity by modulating an applied voltage to the varicap.

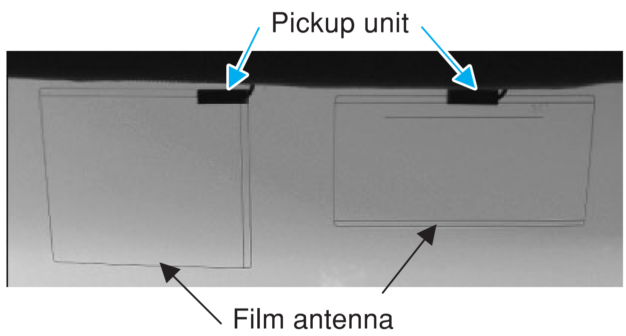

Fig.9 Antenna and Pickup Unit

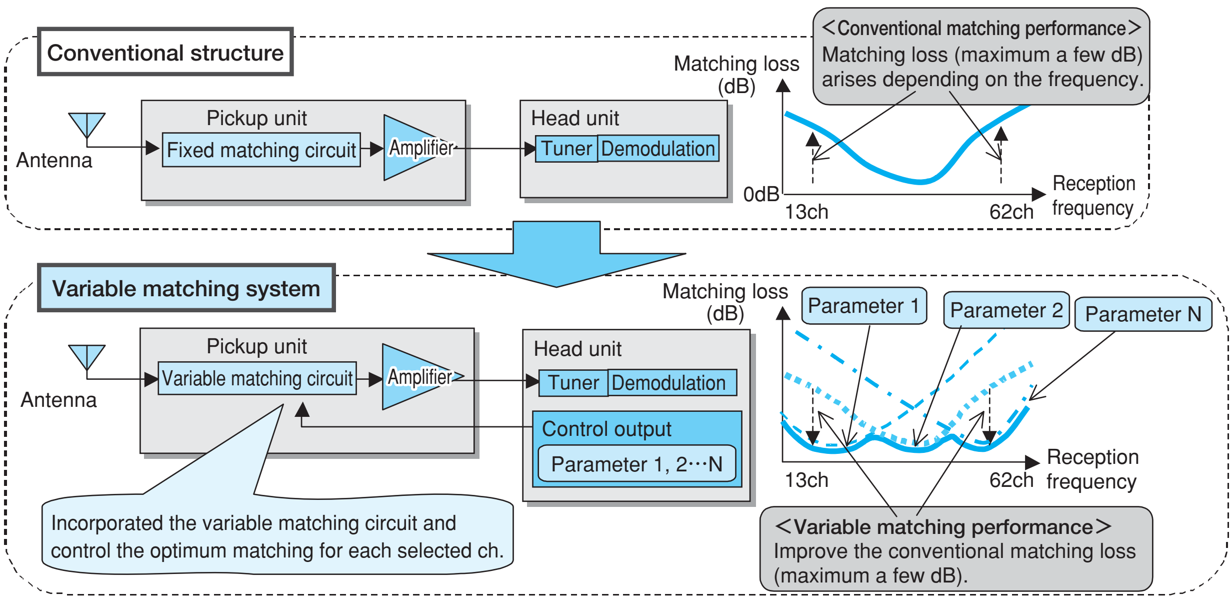

Fig.8 Principle Illustration of Variable Matching System

3.2 System Structure and Signal Superposition

The system structure is shown in **Fig. 10**. Between the receiver of the terrestrial digital broadcasting and the pickup unit, one coaxial cable transmitted the power source and the received signal of the terrestrial digital broadcasting. However, we developed the system/circuit to superimpose the control signal for impedance matching on the power source and the received signal of the terrestrial digital broadcasting. Then we incorporated this system/ circuit into the same size pickup unit as the conventional size. This is the significant achievement and the hardest point for us.

Four antennas are put on the automobile windshield. The impedance is controlled by the inner antenna and the outer antenna, showing the similar impedance characteristics, on the automobile windshield.

Vp(=Va+Vm) that the minimum operating voltage Va of the amplifier and impedance control voltage Vm are superimposed is supplied from the head unit to the pickup unit through the coaxial cable. Vm is set selecting the optimum value in the channel that the receiving control microcomputer receives. In addition, the high-frequency signal, received from the pickup unit to the head unit, is also superimposed and transmitted to the coaxial code.

From Vp to Vm are detected in the matching voltage detection section, and they are applied to the variable matching section. On the other hand, in the amplifier circuit of pickup unit, voltage to be applied varies depending on the change of Vm. We developed the circuit configuration that enables stable operation by devising a bias circuit of transistor used for the amplifier to keep the current (flowing into the collector) constant even if the applied voltage varies.

3.3 Design

We designed the variable matching system as the following flow:

(1) Measurement of frequency characteristic of antenna impedance

(2) Measurement of frequency characteristic of amplifier impedance

(3) Selection of circuit configuration, circuit constant, and voltage Vm with the variable matching system simulator

(4) Verification by actual equipment

Especially in (3), we developed the special simulator so that the width or length of printed wiring board pattern, equivalent circuit of each part, and others can be faithfully described and the calculated values can be reflected in the actual equipment.

Also we used two-layered printed board so the obverse side and reverse side of the pickup unit are electrically connected and we designed with a trial-and-error method. However this time we use four-layered printed board to remove the connection between obverse side and reverse side. This is one of the factors that led to the calculated values being the values found in the actual equipment.

In addition, the number of steps for Vm switching has a close relationship with improvement of sensitivity and cost. We selected the optimum switching step 4, using the developed variable matching system simulator.

Using these methods, we configured the variable matching system in the pickup unit. As a result, the numbers of parts were increased by 9 parts compared with the fixed matching system, but we realized the same size pickup unit as that of the fixed matching system.

The size and the inside of the pickup unit is shown in **Fig. 11**.

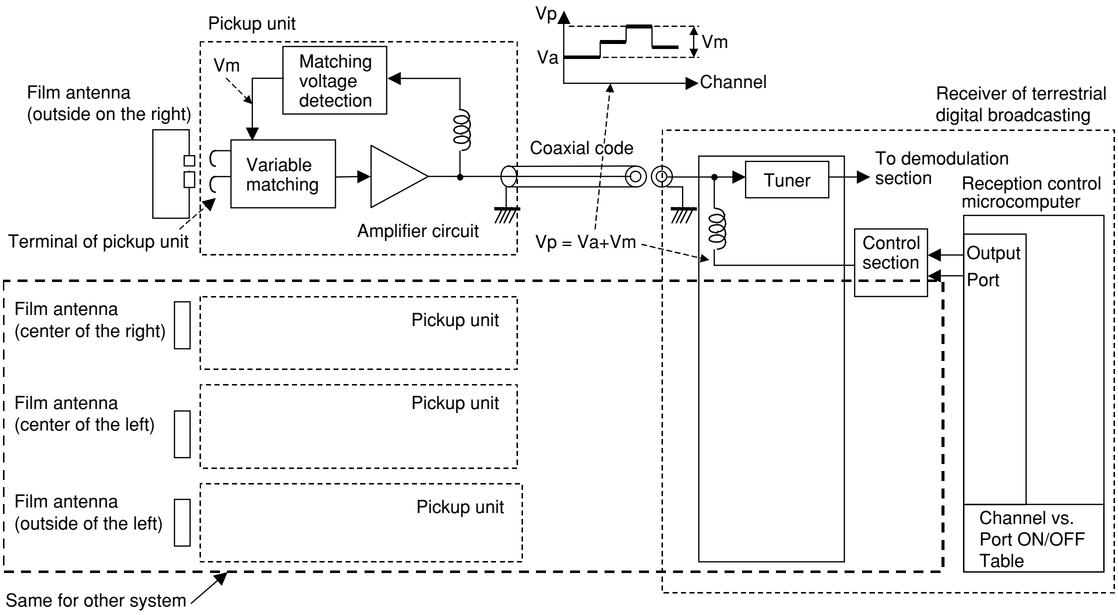

Fig.10 Structure of Variable Matching System

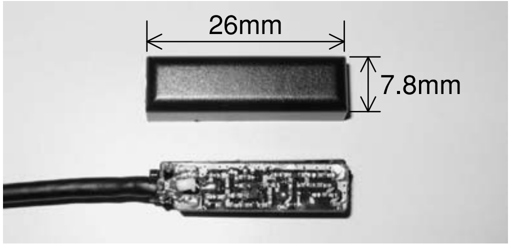

Fig.11 Pickup Unit in Variable Matching System

3.4 Evaluation

The comparison result of reception obtained from the typical driving experiment between the conventional model (fixed matching system and marketed product in 2007) and developed model (variable matching system and marketed product in 2008) is shown in **Fig. 12**. Under this condition, the reception of developed model on whole test course was 92.2% as against that of the conventional model which was 82.3%. We recognized the improvement of approximately 10%.

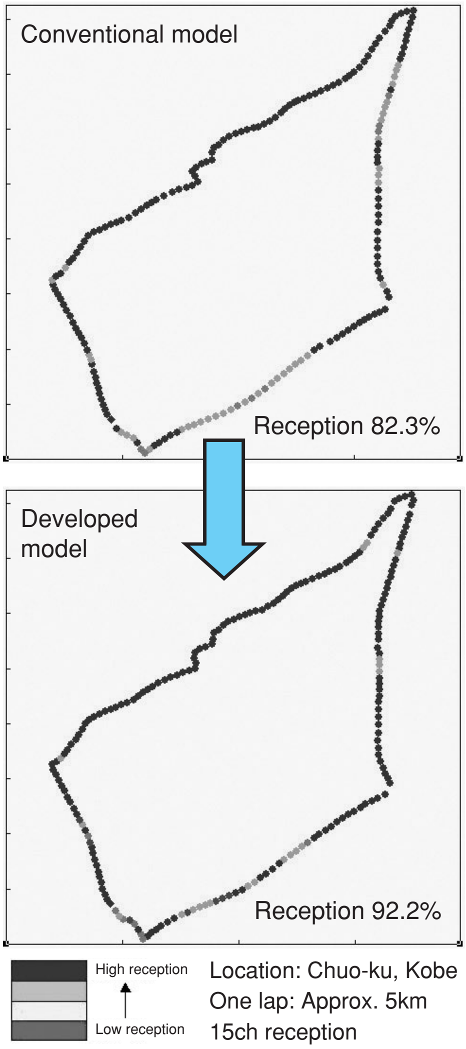

Fig.12 Comparison of Reception Rate with Conventional and Development Product

The receiver sensitivity of the combination of 4 antennas at all frequencies/all directions, compared in the radio frequency anechoic chamber, is improved by 2.7dB, comparing with the conventional model.

This result is equivalent to the coverage expanding by up to approximately 20%.

4 Seamless Switching for Terrestrial Digital Broadcasting

4.1 Background

As for FUJITSU TEN's model with tuner for the Full-seg terrestrial digital broadcasting, automatic switching function for Full seg/One seg has been installed from 2006 autumn model. When we studied the specification of terrestrial digital broadcasting for 2008 model, we conducted the benchmark of the switching function of competitors' products. As a result (**Table 2**), we found the problems that the switching time was longer than the products of competitors and the black image arose when switching.

Table 2 Comparison of Operation with Competitors

Item	Company A	Company B	TEN (Conventional model)
Switching time (Picture/sound)	3 to 4s	1.5 to 2s	3 to 5s
Status in a stand by of switching	Full-seg motion picture (with picture noise)	←	Full-seg still image
Black image when switching	None	Exist	Exist

Therefore, we introduced the simultaneous decode and improved the seamless automatic switching in order to solve the problems above and to improve the picture quality when automatically switching.

4.2 Problems of Conventional Functions and Its Countermeasures

The conventional automatic switching function is to stop the Full-seg decoder and is to start the One-seg decoder when the Full-seg reception has been so bad as not to watch for a preset time period. One seg needs a long cycle of I-Picture so it takes time from the start of decoder to the output of picture and sound. This time was the switching time (**Fig. 13**).

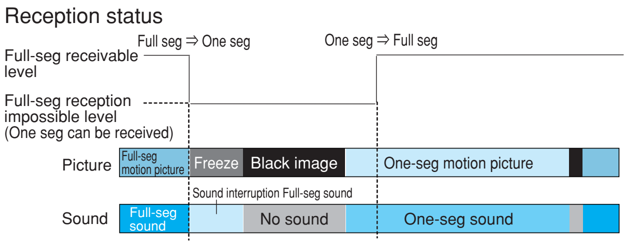

Fig.13 Conventional Automatic Switching

As a countermeasure, we conducted the simultaneous decoder of Full seg/One seg and shortened the switching time to One seg so that the picture and sound of One seg can be output when switching **(Fig. 14)**.

4.3 Design and Evaluation Result

In the 2008 model, we adopted CUP-installed terrestrial digital broadcasting processing LSI that enables the software decoder of One seg. This decodes One seg by software. The software decoder of One seg has the high CUP load so there is a worry that the response of HMI drawing or data broadcasting drawing may deteriorate during the simultaneous decode.

We conducted the design so that the deterioration of Full-seg reception triggers the start of One-seg decoder in order to minimize the simultaneous decode interval **(Fig. 14)**.

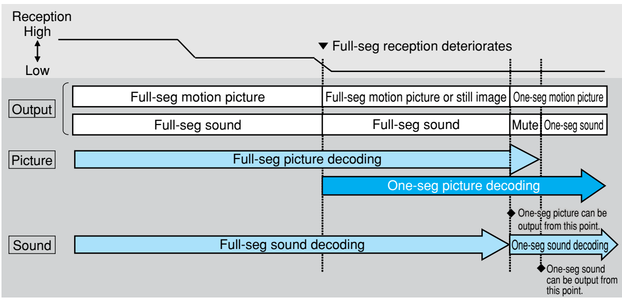

Fig.14 Seamless Switching

The evaluation result between the conventional automatic switching and seamless switching is shown in **Table 3**.

Table 3 Comparison with Conventional Processing

	Conventional automatic switching (s)	Seamless switching (s)
From Full seg to One seg	3	1
From One seg to Full seg	0.6	0.3

As compared to the conventional model, we decreased the switching time by half and eliminated the black image when switching, and we achieved the design target.

5 Conclusion

We introduced "picture digital transmission system" to improve the picture quality, "variable matching system for terrestrial digital broadcasting" and "seamless switching for terrestrial digital broadcasting" to improve the reception of the terrestrial digital broadcasting. These technologies helped us to achieve the nonconventional sharp and high-quality AVN and to differentiate ourselves from competitors.

We will make more effort toward the achievement of high performance that satisfies our customers.

Profiles of Writers

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