Development of 2004 Model HDD AVN

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High-Definition 7-inch VGA Display, Twin 20GB Hard Drive AVN

Satellite images provided by Japan Space Imaging Corporation.

Abstract

Since launching the world's first integrated AVN system onto the market in 1997, our company has been steadily cultivating the market via continuous and innovative evolution of AVN.

Over recent years however, the high market profile of AVN has led rivals to enter the field one after another, resulting in drastic falls in prices and a loss of distinctiveness.

To break out of this situation we developed a new model AVN system that further evolves the audio functions that are our company's strongpoint, incorporating quad-speed audio-recording Music Juke, FMdeTITLE, and virtual 5.1 channel surround supported by CS II. This paper presents the technology involved.

1 Introduction

Since its 1997 commercialization and market launch of an AVN system integrating audio, visual, and navigation functions in 2DIN size, FUJITSU TEN has continually evolved this product by adding triple decks (DVD/CD/MD), a touch panel, large-size VGA capable screen, twin HDDs for high-capacity HDD navigation, Music Juke ("MJ" below), and built-in ETC, among other features.

Unparalleled by any other company, this product concept won high acclaim and established the "AVN" product category in the market. But recent years have seen our rivals introduce their own products in this category one after another. As the pioneer in the field we must respond by achieving even higher levels of differentiation and performance.

Our 2004 model HDD AVN Hi ("2004 model HDD AVN" below) for use in Toyota products incorporates quad-speed audio recording with simultaneous playback by MJ, CDDB (CD database) automatic song information search (FMdeTITLE) and other newly developed technology.

The present paper describes the functions and technology of this product.

Satellite images provided by Japan Space Imaging Corporation. JSI

Fig.1 2004 Model HDD AVN

2 Overview of the product

There follows an overview of 2004 model HDD AVN.

Common items

- Exterior size: 2DIN new general-purpose (W 205.5×H 104×D 165mm)
- Mass: 3.5kg
- Decks: DVD and CD compatible decks
  HDDs: 20GB HDD for navigation
  20GB HDD for audio
- Control operation: Via main body (touch panel + switches on front board)

Display section

- 7-inch wide VGA display
  Screen size: W 156×H 83.28mm
  Number of pixels: 1,152,000 (horizontal 2400×vertical 480)

AV section

- Radio (AM/FM/FM multiplex)
- Television (multichannel capable (up to 62 channels))
- CD (CD-R/RW compatible)
- DVD video playback
- MP3 playback
- MAGICGATE-compatible Memory Stick music playback
- MJ (able to record up to 3,000 tracks)
- CDDB automatic title assignment (auto-titling function) and automatic song information search (FMdeTITLE) for CDDB
- VTR input and rear seat display output

<Features>

Touch panel switches are employed to provide simple switching among sources in this AVN system capable of multiple music source playback. Besides music source switching, these switches also make it simple to obtain split-screen displays including a map. Thus, operability has been enhanced.

Fig.2 Mode menu screen

Fig.3 Split-screen display with map

Fig.5 Zoom-in realistic view of intersection

Further, the 2004 model HDD AVN's quad-speed audio recording feature gives dramatically faster recording, permitting an entire CD album (containing 50 to 60 minutes of recorded material) to be recorded during a relatively short drive such as a shopping trip, whereas the conventional normal-speed audio recording will take several drives to record a complete CD. Also incorporated is a simultaneous record-and-playback function, permitting playback while recording is in progress.

Such unique functions as these put us ahead of our rivals in the field.

Fig.4 Quad-speed audio recording

Navigation section

- HDD navigation
- Equipped with 3-D hybrid sensor
- Agent functions
- Displays zoom-in realistic views of intersections
- Satellite shot functions (with freely adjustable zoom, facility name displays, route guides)
- Continuous FM-VICS reception capability
- Multi window functions

Audio quality section

- Sound field control, graphic equalizer, position selector
- 40W amps×4
- Circle Surround II ("CS II" below)*1

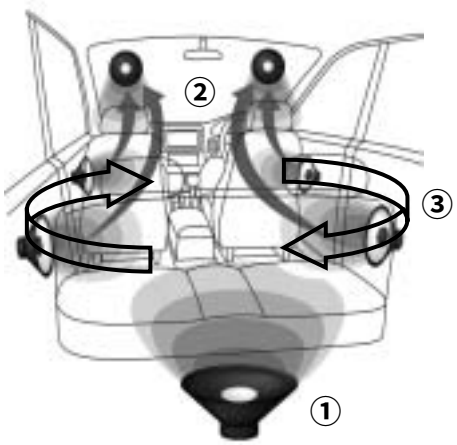

Fig.6 Conceptual representation of CS II sound field control

System upgrade equipment

- CD changer
- MD changer
- ETC unit (automatic expressway toll collection system)
- Back monitor (back-eye camera)
- Rear seat display
- Beacon unit (2-media VICS unit)
- Blind corner monitor
- Steering switch

(*1) This is theater sound realized by employing the SRS Labs, Inc.'s "CS II" home surround technology with additions of our own original technology to suit it for in-vehicle use. CS II is equipped with ① sub-woofer functions, ② squawker / tweeter functions, and ③ surround functions, enabling it to realize an in-vehicle theater simply by using conventional speakers unaltered.

3 System configuration

Overview of system

The 2004 model HDD AVN inherits the design assets of the 2003 model HDD AVN and adds capability for quad-speed recording and simultaneous playback in its MJ section.

It is further equipped for the first time with a CS II compatible DSP offering multichannel (4-channel) enjoyment of 2-channel audio sources.

The system's navigation hardware features the new platform introduced in the 2003 model HDD AVN, which brings major performance improvements.

Fig. 7 shows the product's system configuration.

Except for the newly added functions, the hardware design adheres to the 2003 model HDD AVN.

The items that are changed from the 2003 model HDD AVN are indicated by hatching.

4 MJ's quad-speed audio recording

Development aims

With our earlier HDD AVN we achieved large capacity (20GB) HDD audio recording ahead of our rivals by employing twin HDDs (one for navigation and another for audio).

But nowadays our rivals are marketing HDD products equipped with diverse recording functions. As a result, we have to raise our product's audio recording speed and increase its added value in other ways, so as to give it more distinctive features.

Table 1 lists the simultaneous record-and-playback methods employed by the various companies in their HDD audio recording products.

Table 1 HDD audio-recording products of various companies

As of Feb. 2004

	Launch date	Recording method	Speed factor	Simultaneous playback	Notes
MIT	Apr 2003	MP3	1	●	
PIO	May 2003	ATRAC3	2		
TEN	May 2003	ATRAC3	1	●	2003 model HDD AVN
ALP	Oct 2003	ATRAC3	1	●	
CLA	Nov 2003	MP3	1	●	
KEN	Feb 2004	Original	3		Reversible conversion
TEN	May 2004	ATRAC3	4	●	Simultaneous recording/ playback capable
SONY	Jun 2004	ATRAC3	8		

Formerly we employed the mainstream method that permitted listening to a CD while it was recorded at the normal speed. But to answer calls by many users for high-speed recording capability, we set a development target of quad speed recording plus simultaneous playback for the 2004 model HDD AVN.

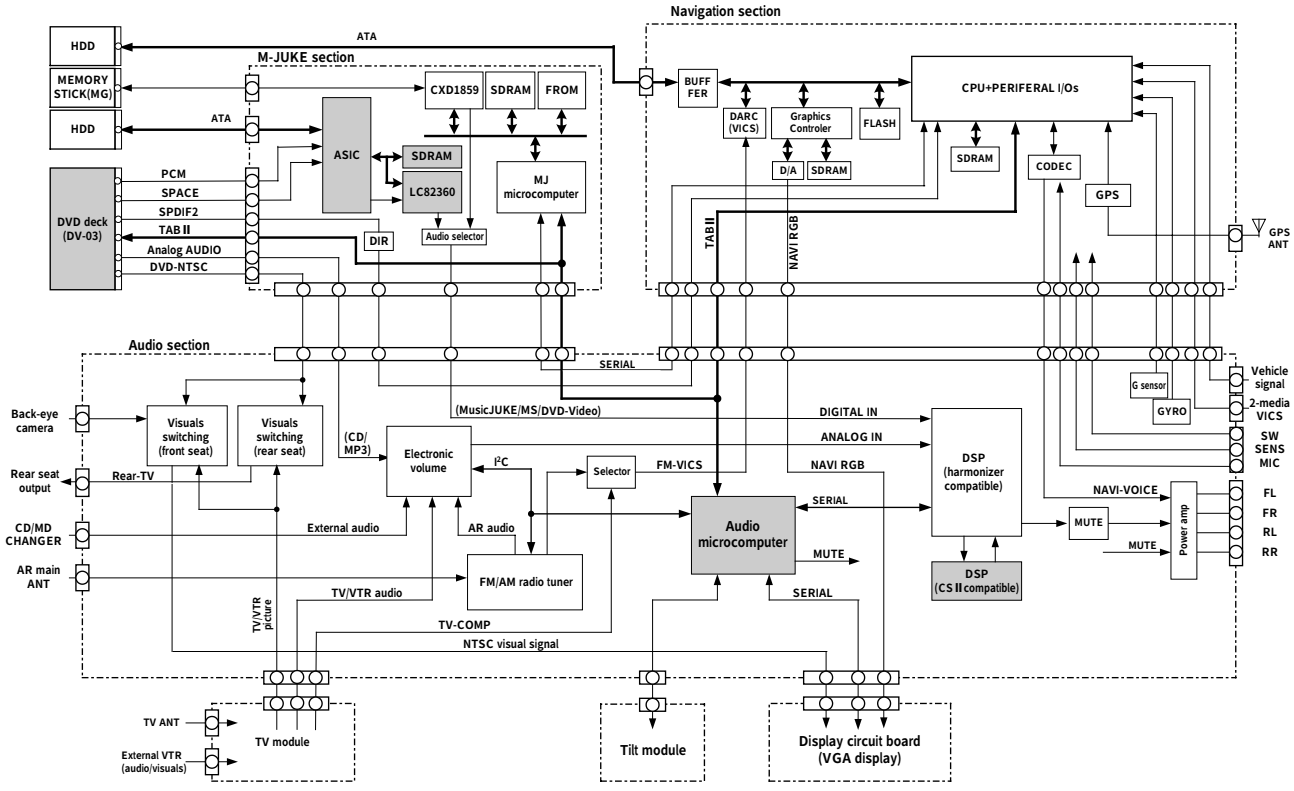

Fig.7 System configuration

Development items

In the development of the 2004 model HDD AVN we adopted 3 items in order to upgrade the system's functions and performance. These items are described below.

(1) Quad-speed playback capable deck (DV-03)

In order to realize quad-speed recording it is necessary to play back the CD at quad speed. The conventional DVD deck (DV-01) used CAV (constant angular velocity) control,which resulted in a discrepancy in the data readout speeds between the CD's outer and inner circumferences, rendering it impossible to play back the CD at 4 times the normal speed.

The newly-developed DV-03 shares its deck mechanism section in common with the DV-01, but has a freshly-designed signal processing section and control section, and employs a CLV (constant linear velocity) control method. These new elements make it capable of 3-channel serial output of quad-speed data.

(2) ATRAC3 Encoder/Decoder LSI (LC82360)

The LC82360 (Sanyo Electric) is an LSI with built-in encoder/decoder circuits (hardware) employing the ATRAC3 (adaptive transform acoustic coding 3) method. The encoder circuits and decoder circuits can be operated independently of each other.

The earlier 2003 model HDD AVN employed the CXD1859 (Sony), which realized ATRAC3 encoder/decoder and Memory Stick capability but had insufficient processing capacity to realize quad-speed encoding and decoding simultaneously.

It was decided to adopt the LC82360 because it permits encoding (max. 24 times the speed on the catalog) at quad and faster speeds, as well as simultaneous decoding.

Fig. 8 is a block diagram of the LC82360's interior.

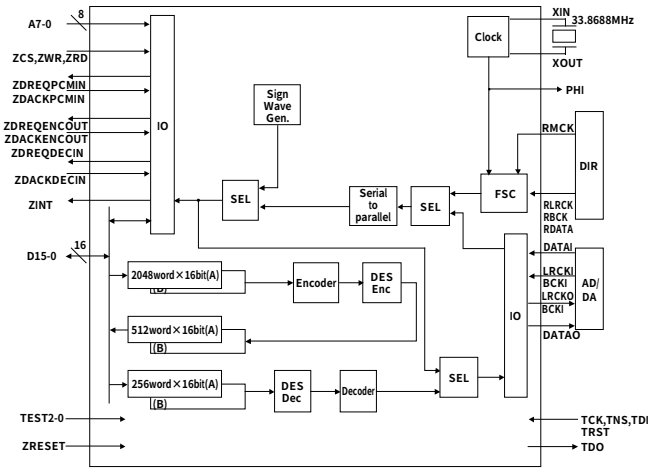

Fig.8 Block diagram of LC82360 interior

(3) ASIC for MJ (135926-00900880)

In order to use the LC82360 to realize simultaneous recording and playback (including fast-forward and fast-rewind), the bus load during recording/playback had to be lessened.

Accordingly, we designed the 2004 model HDD AVN such that the flow of data to the CPU bus is periodically halted, and furthermore developed an ASIC for MJ that assists data transfer via the hardware, so as to lessen the CPU's processing load.

With this ASIC, data transfer between the LC82360 and the SDRAM is controlled via hardware, thus effecting a major simplification of the software control and an improvement in the processing margins (by lessening the bus load and reducing the frequency of interrupt processing, etc.). (Further details will be found in section 5 below).

5 Development of ASIC for MJ

As Fig. 9 shows, this ASIC is a semi-customized IC with the purpose of providing capability for quad-speed recording of music CDs.

Circuit configuration

• DVD interface section

Performs masking control of the inter-track data among the PCM (pulse code modulation) 3-channel serial interface signals.

• DMAC (DMA controller) section

Transfers data between ATRAC3 encoder/decoder LSI (LC82360) and SDRAM, via DMA (direct memory access).

• ATA (AT attachment) arbitration control section

Conforms to ATA/ATAPI-5 standards.

The function of this section is to arbitrate accessing of the HDD by the microcomputer that controls MJ (referred to as the "MJ microcomputer" below) and the microcomputer that controls navigation (referred to as the "navigation microcomputer" below). It is used in products configured with a single HDD, such as a single HDD AVN system.

Description of circuit blocks

(1) DVD interface section

A music CD has multiple tracks, the spaces between which may be blank or contain link music, etc.

In order to record the CD's tracks into the HDD without damaging such inter-track music data and without causing any awkwardness in continuity between tracks,

Note: Since the 2004 model HDD AVN has twin HDDs it does not use this function, but it contains the function nevertheless because both single- and twin-HDD AVN employ the same ASIC. The processing of the main circuit blocks is described below.

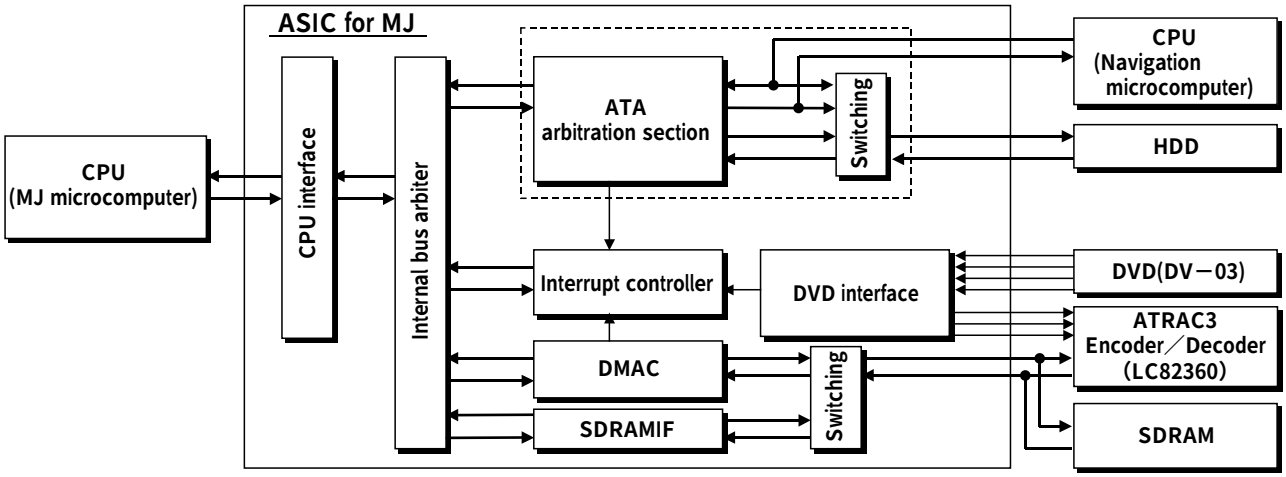

Fig.9 Block diagram

the start and finish of each track, including an inter-track space where applicable, must be identified so that just the requisite recording duration of music data is transferred to and encoded by the LC82360.

The means used for transferring the data to the LC82360 is a PCM 3-channel serial interface.

The DVD interface section identifies the requisite recording duration of music data by means of SPACE signals that it receives from the DVD deck section. It uses these signals to halt data transfer to the LC82360 when the data is not requisite. Halting data transfer in this way prevents encoding of redundant data.

Recording the data only when the SPACE signal is "high" enables awkwardness-free playback of inter-track music. Fig. 10 provides a timing chart for the music data and SPACE signal.

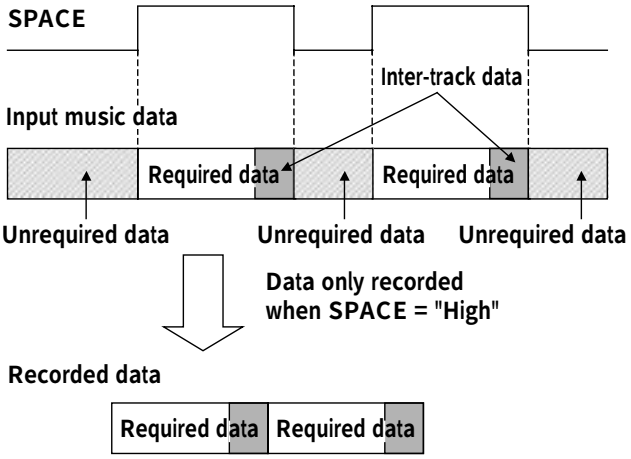

Fig.10 Timing chart for music data and SPACE signal

(2) DMAC (DMA controller) section

The DMAC section controls DMA transfer between the LC82360 and SDRAM (for caching recorded data) for recording and playback of music data. This section's functions lessen the MJ microcomputer's load and permit realization of quad-speed recording with simultaneous playback. There is one DMAC for recording and a separate DMAC for playback. During recording, data encoded by the LC82360 is transferred from the LC82360 to the SDRAM, while during playback the encoded data stored in the SDRAM is transferred to the LC82360.

There are 4 DMA transfer buffers, 2 for recording and 2 for playback, labeled A and B in each case. As can be seen from Fig. 11, these buffers can be compatible with the desired lead address and buffer size in the caching SDRAM's address space.

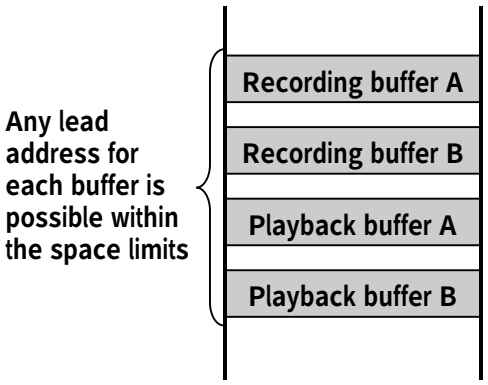

Fig.11 Memory map of SDRAM for cache

The use of dual buffers provides the following 2 benefits:

①While the MJ microcomputer is transferring the music data saved in recording buffer A to the HDD, the next batch of music data from LC82360 can be saved into recording buffer B (refer to Fig. 12).

②While LC82360 is playing back music data saved in playback buffer A, the MJ microcomputer can save the next batch of music data from the HDD into playback buffer B. Thus, data can be transferred by switching the recording and the playback buffers in the sequence buffer A → buffer B → buffer A. In this way, music can be recorded and played back without any audio jumping.

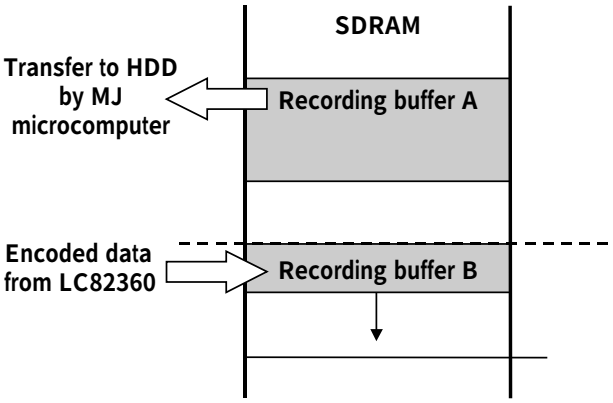

Fig.12 Audio recording operation

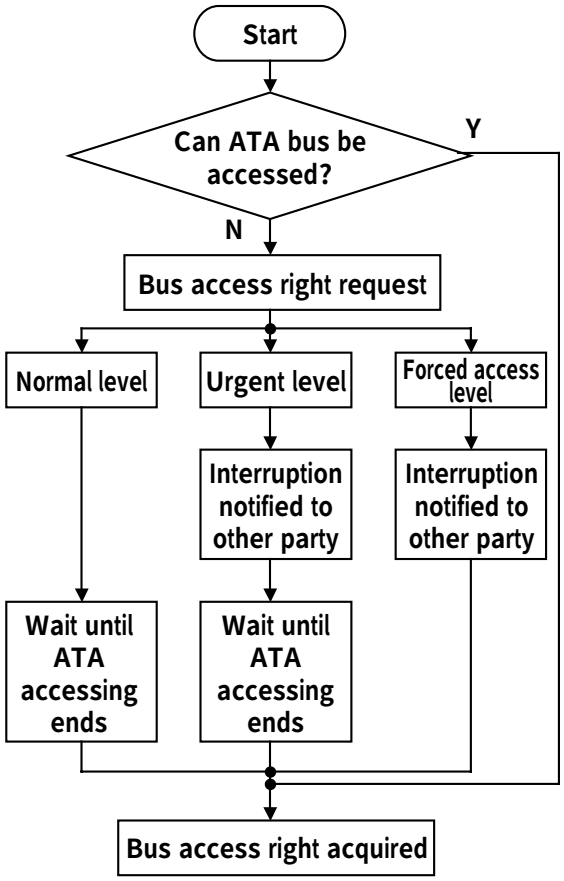

Fig.13 ATA negotiation processing

Further, if music data from LC82360 is simultaneously saved into recording buffer A and playback buffer A, then while the MJ microcomputer is saving (recording) data from recording buffer A into the HDD, the same data can be sent from playback buffer A to LC82360 (played back by LC82360), thus realizing "simultaneous recording and playback" whereby the music can be played back without waiting for recording to end.

(3) ATA arbitration section

In a single HDD AVN system where a single HDD is used in common for music data and map data, the ATA arbitration section arbitrates between accessing of the HDD by the MJ microcomputer and by the navigation microcomputer.

A flowchart of the ATA arbitration process is shown in Figure 13.

Physical specifications for ASIC

The physical specifications for the ASIC are listed in Table 2, and its exterior appearance is shown in Fig. 14.

Table 2 Physical specifications for ASIC

Package	240-pin LQFP (0.5mm pitch, plastic package)
Process	0.35mm gate array
Power voltage	3.3 ± 0.3V

Fig.14 Appearance of ASIC

6 FMdeTITLE

FMdeTITLE enables users to assign titles to newly released CDs, and to do so simply and at no cost. It is the first service of its kind in the world and has been realized through a business tie-up among 4 companies: Gracenote which owns the CDDBs; the Media Click Inc. which produces the pickups for the CDDBs and the data for broadcasting; the FM Tokyo which actually transmits the data; and FUJITSU TEN.

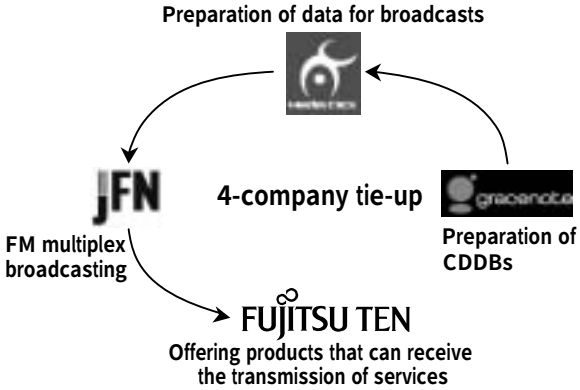

Fig.15 Framework for FMdeTITLE service

Our 2004 model HDD AVN is ahead of its rivals in having built-in functions to receive this service, which permits users to acquire cost-free CDDBs of up to 50 titles that are broadcast every week by Japan FM Network (JFN) stations (comprising 37 companies nationwide). These functions were developed with the following items in mind:

(1) Convenience

To acquire the data it is necessary to be tuned in to a JFN network station, since it is these stations that broadcast the data. The FMdeTITLE functions extract the applicable station for the user's location (for example, Tokyo FM in Tokyo, fmosaka in Osaka, and FMA Nagoya in Nagoya) from the navigation section's own-car position data and area preset data, and automatically tunes in to that station.

Thus, as users are driving along they will find that new titles have been acquired without their having had to perform any particular operation.

(2) Symbiosis with FM VICS

Since the 2004 model HDD AVN is equipped with just 1 FM multiplex decoder, it is unable to receive FM VICS, FM text and FMdeTITLE broadcasts simultaneously. FM VICS in particular precludes simultaneous reception because it is broadcast by completely different stations from the others. This makes it necessary to select either reception of FM VICS (traffic jam/restriction information) or reception of the CDDBs.

Accordingly, we have provided a mechanism whereby each time the engine is started up, a check is run to determine whether all of the CDDB data for the week in question has been acquired; continued CDDB reception is selected if the data acquisition is still in progress, and VICS reception is selected otherwise. This is implemented even if the user has set (selected) CDDB reception; indeed, there is no need for the user to make any prior setting to select between FM VICS and CDDB. Thanks to this feature, utilization of FM multiplex content entails no wasteful reception.

Fig.16 Checking of titles received via FMdeTITLE

System configuration and control software

FMdeTITLE data are acquired by the FM multiplex decoder installed in the navigation section, transferred to MJ, and stored in the HDD. As soon as all of the data broadcast for a particular week have been received, reception is automatically switched over to VICS, thus realizing FM multiplex reception at a high level of efficiency.

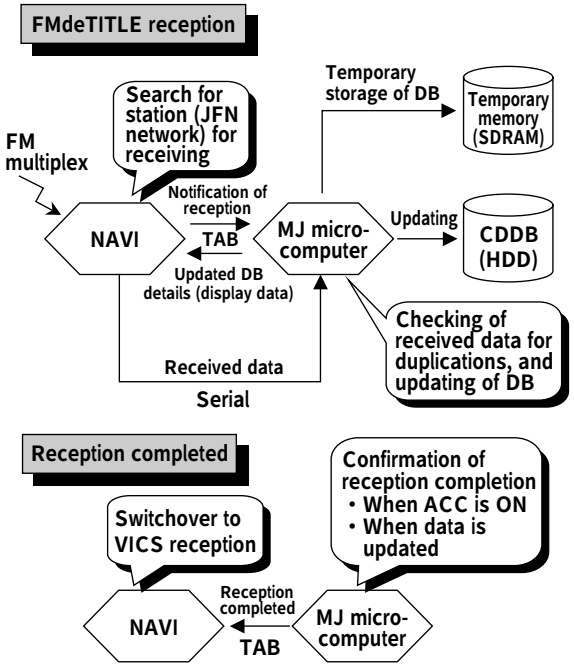

Fig.17 Data control for FMdeTITLE

While the MJ functions or Memory Stick functions are in use, update processing is deferred and CDDB data is temporarily stored in the SDRAM. Then as soon as operation shifts to another mode or the user gives an update instruction, update processing is implemented based on the data stored in the SDRAM. In this way, the occurrence of incomplete data is reduced. Sufficient memory is secured in the SDRAM's buffers to accumulate the data broadcast during 1 week.

Further, the CDDB repeat search function has been improved by a specification change such that after a CDDB update, a repeat search can be run to find title information for recorded tracks that had no title information assigned them.

This has been realized by adding a TOC DB, necessary for CDDB searching, to the recorded track management DB.

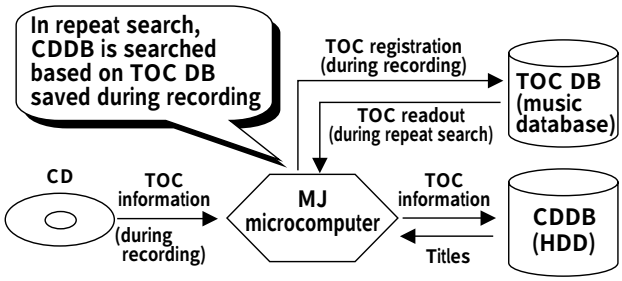

Fig.18 CDDB repeat search function

7 Conclusion

Above we have described the development aims and technology for the 2004 model HDD AVN employing MJ quad-speed recording and FMdeTITLE service functions.

Able to play back music CDs while simultaneously recording them at quad speed, and realizing - for the first time in the world-technology for acquiring new CD track title databases from FM radio, this AVN system offers users HDD audio enjoyment with greater convenience than ever before.

Our intention for the future is to go on developing state-of-the-art HDD AVN pursuing entertainment with high levels of sophistication and performance.

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  "FM de TITLE" FUJITSU TEN LIMITED

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