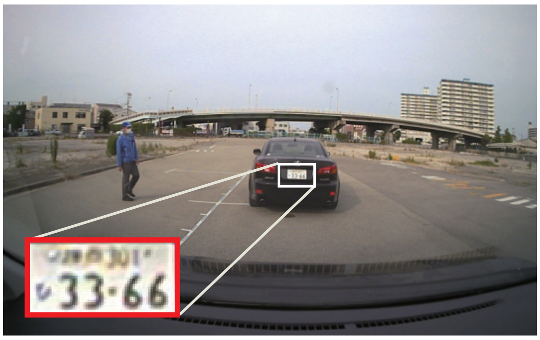
Development of High-Definition Drive Recorder

Hiroaki KAWANISHI
Ryuichi MORIMOTO
Shingo TAGUCHI



Abstract

Since 2005, FUJITSU TEN has developed a drive recorder as a product that contributes to safety and security in a car society, and has widely offered the product that drivers from ordinary drivers to professional drivers of transportation companies, etc. can use. Recently, the recognition of the drive recorder in society has improved, and at the same time expectations are growing. For example, the utilization range of the video recorded by the drive recorder has spread to usual driving records, to say nothing of possible accidents. The video has come to be utilized as safe driving awareness-raising education and a user's driving record. In the future, utilization as one of the monitoring cameras is also under consideration. In response to the spread of the utilization range like this, the drive recorder is expected to evolve into the product that records clearer video with high quality.

We have developed the high-image quality drive recorder to meet such expectations, and started selling it in the summer of 2014. This paper mainly explains, as our efforts for realizing high-image quality, the development of a camera module and the measures against noise accompanying high-image quality which are required for in-vehicle apparatus.

1 Introduction

A drive recorder is a product that has appeared mainly for the purpose of recording video with an impact on a driving vehicle as a trigger, and grasping the state of an accident. In recent years, because of influences of the videos recorded by the drive recorder broadcast by media, interests in the drive recorder are ever-increasing. Also, users' expectations are extending not only to grasping the accident state, but also to high image quality to enjoy the driving records while driving.

Under such circumstances, recently, the drive recorder has shifted from the conventional 0.3 megapixels (VGA size) analog camera type to the high-pixel digital camera type having a megapixel (HD size) or more. In addition, due to entry of various manufacturers, the market is growing substantially with the keywords, high pixel and high image quality.

This time, therefore, we have developed a new-model drive recorder under the theme of high image quality which is highly expected by users. This paper explains our efforts for high image quality and challenges associated with it.

2 Outline of Newly Developed Drive Recorder

2.1 Product Lineup

As well as the conventional models, the two types have been adopted. (**Fig. 1**)

(a) Integrated type (b) Separate type

Fig.1 Product Lineup of Drive Recorder

(a) The integrated type incorporates a camera module in the body, which makes it possible to easily install the product to a vehicle.

(b) Separate type places importance on appearance by separating the camera from the body, and by reducing the portion installed to the windshield.

2.2 Outline of Functions

FUJITSU TEN's drive recorder consists of the blocks shown in **Fig. 2**. The following sections explain the outline of main functions of the drive recorder.

(1) Video recording function

①Creation of MP4 video file

The CPU converts the video and audio data input from the camera module and a microphone into the MP4 format (H.264 + AAC compression), and records it in a microSD card. The video size is 1,280 × 720 (HD size), the frame rate is 28fps, and the bit rate is 3,600kbps by default (can be changed by user settings).

②Recording timing

In synchronization with ON/OFF of a vehicle power supply (accessory power supply), the CPU automatically starts/stops recording in accordance with starting/stopping the vehicle driving. It constantly records video while the vehicle is in motion.

③Video file configuration and recording time

Video files are divided by 36Mbyte (approx. 80 seconds), and the accessory 4GByte microSD card allows about 150-minute recording (in the standard quality mode). When its recording capacity reaches an upper limit, the oldest video file is overwritten first.

(2) Video protection function, Voice guidance

①Video protection function

The G sensor built in the body detects the acceleration when starting/stopping a vehicle and the impact of a collision (hereinafter, collectively referred to as "vehicle G"). When the detected vehicle G exceeds a set threshold (Standard setting: 0.5G; It can be changed by user settings), the video files including the video of total 20 seconds before and after the event (Before: 12 seconds / After: 8 seconds) are excluded from the files to be overwritten, and they are protected.

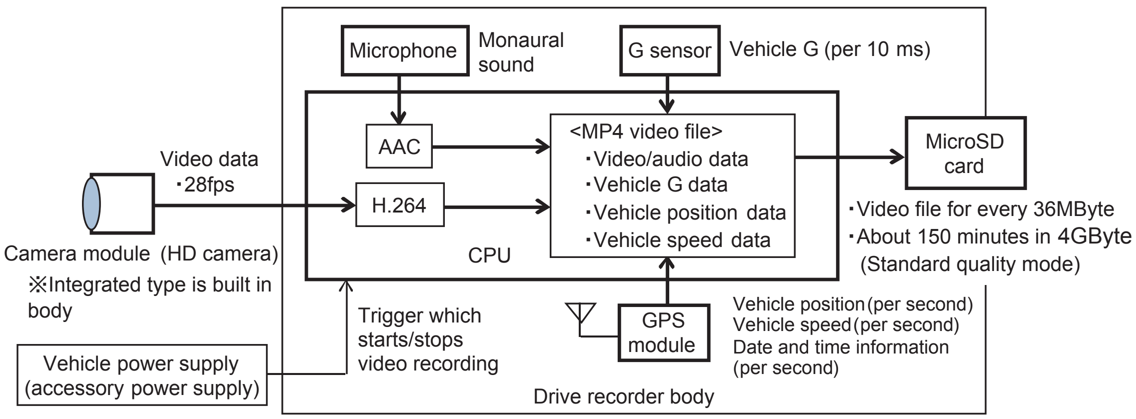


Fig.2 Block Diagram of Drive Recorder

②**Voice guidance function (Separate type only)**

It is the function of diagnosing a drive from the detected vehicle G and calling the driver's attention. In the case where it is determined that abrupt start, sudden braking, or abrupt steering is detected, a voice message warns the driver. Thus, the function contributes to the improvement in safe driving awareness and fuel-efficient driving.

(3) Recording of host vehicle position information / vehicle speed, Date and time correction

The CPU obtains the host vehicle position and vehicle speed information that is output from the GPS module built in the body every second during the constant recording. In addition, the date and time information is corrected based on the information obtained from GPS.

Since the vehicle G, host vehicle position, and vehicle speed are stored as header information in the MP4 video file, the video and the timing can be checked together by using an exclusive viewer. **Fig. 3** shows the screen layout of the exclusive viewer.

Fig.3 Information Displayed by Exclusive Viewer

3 Efforts for High Image Quality

3.1 Determination of Image Quality Target

In the new model, as one of the indicators of high image quality, the letters on the license plate of a counter vehicle can be checked, which has received many requests from the market. To embody developmental target values, we have actually conducted hearings with taxi companies and others. Consequently, the visibility for checking 4-digit number of the license plate even under the following conditions has been set as a target (If the number with four digits and the car model are known, they will be the important information at the time of an accident).

- **Camera-to-subject distance (Fig. 4)**
  Front of host vehicle: 7m, Adjacent lanes: 5m
- **Ambient brightness:** Daytime, Backlight state, Evening, and Night (headlight irradiation)
- **Relative velocity:** 0km/h to 10km/h

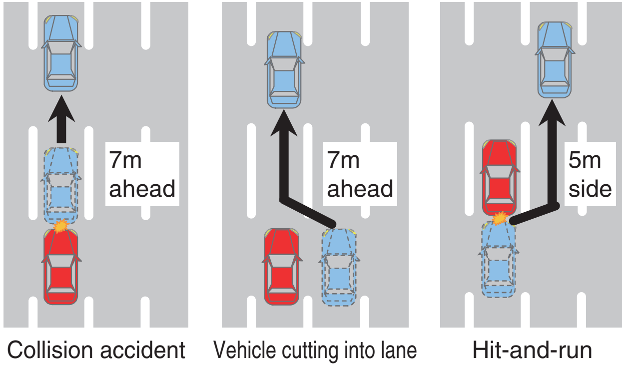


Fig.4 Setting of Target Values

3.2 Selection of Camera Module

The four major factors in determining the image quality among the components constituting a camera module are as follows:

①**Number of pixels of image sensor**
②**Dynamic range of image sensor**
③**Angle of view / shape of camera lens**
④**Quality of material of camera lens**

In order to achieve the target value for the visibility of the license plate of the front vehicle, the number of pixels of the image sensor and a dynamic range become important. Thus, we have selected 1.0 megapixel (CMOS type) image sensor that has the maximum number of pixels as in-vehicle image sensor. In addition, by selecting a relatively large 1/2.7-inch sensor with HDR (High Dynamic Range) function compared to other drive recorders, the dynamic range can be increased, and the license plate can be checked even in the glare of headlights without blown-out highlights.

Next, as for the visibility in the side direction, the angle of view and shape of the camera lens become important. It is necessary to secure a wide angle of view so as to grasp the situation as drive recorder and to secure the resolution to check the license plate of the vehicle in an adjacent lane. Therefore, the camera lens is designed to have a 110-degree horizontal angle of view, a 70-degree vertical angle of view, and high resolution around the center of the lens.

Finally, since the drive recorder is installed to the windshield and is exposed to high-temperature environment, the quality of the material of its camera lens becomes important. To prevent the occurrence of out-of-focus images, etc. even at high temperature of midsummer, we have selected the mixed type of glass and plastics (combination of a plurality of lenses that have different materials).

A glass lens has advantages that it is hard, hardly damaged, less deformed by temperature change, and stable in optical property. On the other hand, since it is hardly processed, the cost is increased.

A plastic lens has high resistance to shock, and is hardly broken. It also has an advantage that the cost is reduced compared to the glass lens because it is easily processed. However, since it has a large coefficient of thermal expansion, there is concern that when the temperature becomes high, the camera lens is out of focus and video is blurred (resolution is lowered).

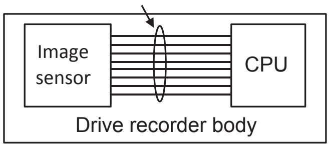
The mixed type selected this time is more expensive than the lens made of 100% plastic, but it became able to maintain high resolution even in a high-temperature environment.

3.3 Suppression of Electromagnetic Interference to Other Devices as In-Vehicle Device

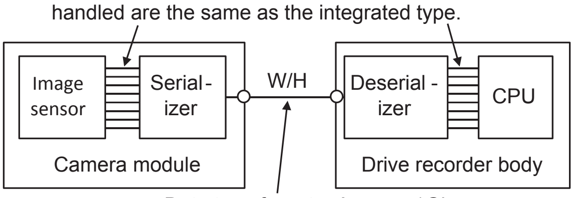
One of the quality requirements required as in-vehicle device is suppression of the interference to other devices. Since especially the drive recorder is installed to the windshield, the distances from antennas for ETC, GPS navigation systems, and digital TV, etc. become very short. When the electromagnetic wave noise radiated from the drive recorder (hereinafter, referred to as radiation noise) is received by their antennas, the function becomes unusable in the worst case. Therefore, unnecessary radiation noise needs to be minimized. Quite a few commercially-available drive recorders particularly affect the reception performance of the digital TV, and cause customer dissatisfaction.

This time, the number of pixels of the camera is changed to a million pixels for making image quality higher. Since the amount of the video data to be handled is increased in accordance with the change, acceleration of the data transfer clock (from 27 MHz to 68 MHz) is performed. Therefore, reducing high-bandwidth radiation noise is a challenge.

Especially in the case of the separate type, as shown in **Fig. 5**, a digital signal of approximately 1 Gbps passes through the wire harness (hereinafter, W/H) between the camera module and the drive recorder body. Since the W/H is disposed near the digital TV antennas, suppressing the separate type's radiation noise was the biggest challenge in this development. The details are explained in the next chapter.



(a) Integrated-type data transfer



(b) Separate-type data transfer

Fig.5 Video Transmission

4 How Separate-Type Video Transmission Works and Suppression of Noise

4.1 Transmission System

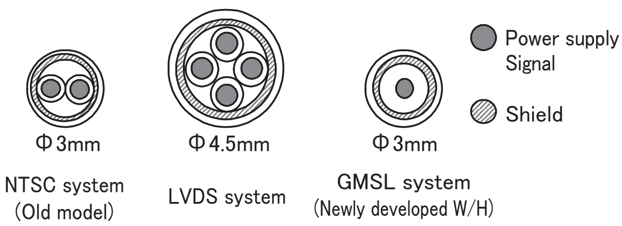
In the old model, the separate type's video transmission system was the analog NTSC system. The video size that can be transmitted by this system is up to VGA. Since the new model transmits HD-sized video, a digital video transmission system is required to be adopted. In the digital video transmission, generally, the radiation noise in the transmission path is suppressed by reducing the amplitude level of a transmitting signal and by adopting the differential system. Typical transmission systems are LVDS (Low Voltage Differential Signaling) and CML (Current Mode Logic). However, in these systems, the number of core wires for transmission increases, and the W/H inevitably increases in diameter (The W/H diameter is Φ3 mm in the analog NTSC transmission system, but it is Φ4.5 mm in LVDS and CML).

Since drive recorders are currently post-installed to finished vehicles, thickening of the W/H diameter leads to deterioration of the workability when installing the device. If wages for installation at dealers or the like become high and the user's burden of costs increases, our product competitiveness may be decreased. For this reason, FUJITSU TEN did not adopt LVDS and CML that cause the W/H diameter to become large.

Therefore, as an alternative transmission system, we have adopted the GMSL (Gigabit Multimedia Serial Link) system suggested by Maxim Integrated Products, Inc. This system bi-directionally transmits a video signal and a control signal at gigabit rates. By superimposing a camera power supply on the signal, a single core coaxial wire can be used. This allows thinning of W/H, and the same W/H diameter Φ3mm as the old model can be achieved. (**Fig. 6**)

Name	LVDS	CML	GMSL
System	Voltage drive; Differential transmission	Current drive; Differential transmission	Current drive; Single-ended transmission
Communication direction	One-way	One-way	Two-way
Communication speed	Up to 1.5Gbps	Up to 3.12Gbps	Up to 3.12Gbps
Harness configuration	2 lines for signal, 1 line for power supply, 1 line for ground, Shield	2 lines for signal, 1 line for power supply, 1 line for ground, Shield	1 line for signal (power supply superimposed), Shield (double as ground)
Harness diameter	ϕ4.5mm	ϕ4.5mm	ϕ3mm

(a) Comparison of digital video transmission systems



(b) Comparison of W/H

Fig.6 Comparison of Video Transmission Systems and W/H

4.2 Configuration of GMSL Transmission Circuit and Suppression of Radiation Noise

Fig. 7 shows the configuration of the newly adopted GMSL system. In the separate type, the configuration from the camera module to the camera W/H (coaxial cable) is disposed on the windshield, and is adjacent to (run parallel to) antennas of other devices, especially to the TV antennas. Therefore, it is necessary to suppress the radiation noise from the camera module and the camera W/H.

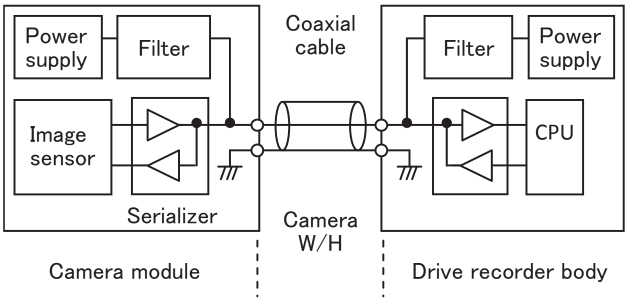


Fig.7 Configuration of GMSL System

In order to reduce the radiation noise in the transmission of high-speed signals, characteristic impedance matching (to keep the impedance constant) in the transmission path becomes important. When the impedance is not matched, a standing wave by signal reflection occurs on the transmission path. The standing wave causes an increase in radiation noise.

This time, we have worked on matching the impedance among the camera module side circuit board, camera W/H, and drive recorder body side circuit board with the impedance 50Ω of the W/H to be used. The following two points particularly require the impedance matching:

①Junction of camera body and W/H

②Circuit board of drive recorder body

With regard to ①, in cooperation with a camera module manufacturer, we added a filter circuit to the video transmission path inside the camera, and adjusted the board pattern to reduce the radiation noise.

With regard to ②, it is important to design the board pattern that prevents the occurrence of signal reflection between the camera W/H connector land and a receiver IC (deserializer). The receiver IC is disposed on the same component side as the connector (first layer of the circuit board), and the characteristic impedance is adjusted to 50 Ω so that the pattern wiring becomes the shortest. **Fig. 8** shows the designed pattern, and its concept is described below.

(a) To prevent the signal reflection in the pattern drawn from the connector land, the pattern is drawn with the same width as the land. Since the pattern width is wide, a microstrip line is formed between the first layer and the fourth layer of the circuit board, and the impedance is adjusted to 50Ω.

(b) Since the land shape becomes smaller in the terminal connection part of the receiver IC, the pattern width is gradually narrowed. Since the pattern width is narrow, a microstrip line is formed between the first layer and the second layer of the circuit board, and the impedance is adjusted to 50Ω.

(c) It is necessary to design the part connected to the power supply so as not to affect the impedance of between the connector land and the receiver IC. In order to extract a high-frequency signal in the GMSL communication band (around 1GHz) from the signal transmission line, the impedance of the connection part to the signal transmission line is designed so that it becomes ten times (500Ω) or more of the W/H impedance. As a result of adjusting the filter circuit constant connected to the power supply and the like, the impedance of 550Ω or more was secured.

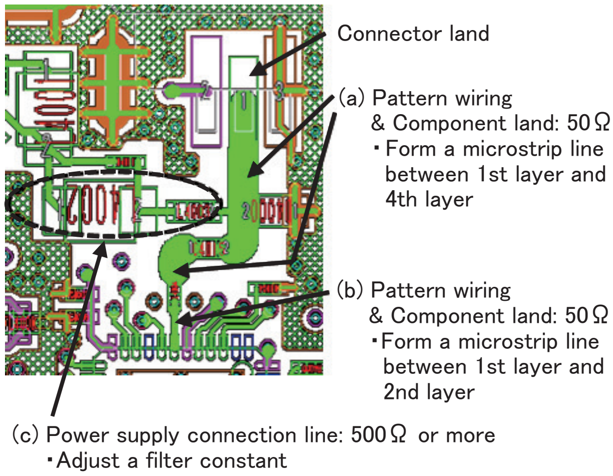


Fig.8 Impedance Adjustment of Circuit Board

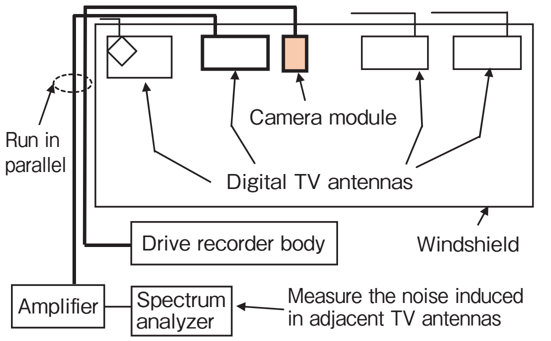
By performing the above-mentioned measures, it becomes possible to set the impedance among the camera, W/H, and drive recorder body to about 50Ω, and the radiation noise has satisfied the in-house standard.

4.3 Confirmation of Influence on Digital TV

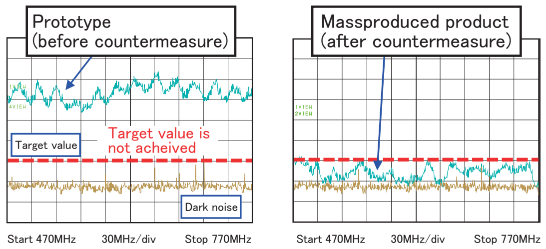
As an example of effects of these measures, the result of confirming the influence on digital TV reception performance that is often taken up as a complaint in the market is shown below.

Fig. 9 shows the result of measuring the field strength of the radiation noise from the drive recorder which is induced in digital TV antennas (which is received by antennas). If the noise level is not less than the field strength of airwaves to be originally received to a certain extent, it interferes with TV reception. Therefore, as the target value of the radiation noise, it is necessary to fall below the field strength of the weak electric field (the state where the distance from a TV station is long, and the field strength of airwaves is weak, so-called a poor state of radio waves) which allows our AVN to barely receive television signals.

As a result of implementing the measures such as impedance matching from the camera to the drive recorder body as mentioned above, the radiation noise can be suppressed to the level below the target value.



(a) Method of measuring radiation noise from drive recorder



(b) Amount of radiation noise induced in antennas

Fig.9 Measurement of Radiation Noise from Drive Recorder

Fig. 10 shows the result of measuring the radiation noise from other companies' drive recorders under the similar conditions. Although the noise level of the Company A's product is high, the noise levels of the Company B's / Company C's products are kept low. In addition, Company B and Company C explain that they take measures against the radiation noise in their product catalogs, etc. Our product shows the noise level equal to those Company B and Company C products.

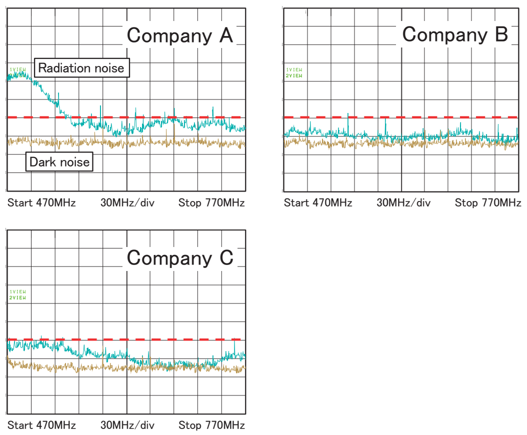


Fig.10 Measurement Results of Radiation Noise from Products of Other Companies

In order to confirm the effect, we actually installed the product for which a measure is taken to the vehicle, and examined a decrease in the TV reception rate when the vehicle runs on the course in the weak electric field. As a result, we confirmed that the level of screen rock or the like due to the reception stop is not much different even when the drive recorder is uninstalled.

5 Future Development

As for the product developed this time, we have been promoting expansion into business-use and aftermarket / dealer option drive recorders, and the in-vehicle server to be developed in the future. At the same time, we are thinking of a service business utilizing recorded data such as driving images and the host vehicle position.

In one example, a white line is detected and the distance from the white line is calculated by image recognition processing in real time, in addition to giving an alarm [in conformity with safety standards and NCAP (New Car Assessment Program)], the result is recoded as time-series data. The recorded data is utilized for evaluating a driver's driving results and educating the driver about safe driving (such as detection of unsteady driving).

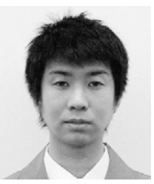
In addition, hiyari-hatto (meaning close call or near miss) points are automatically detected through the analysis of the recorded images and time-series data to improve the efficiency of the current visual operations by customers, and we plan to create "Hiyari-hatto database" (in cooperation with Fujitsu).

6 Conclusion

The data recorded in the drive recorder is widening its utilization range more and more as probe data. To meet such expectations, we would like to place the network-type drive recorder including the center side as well as the in-vehicle device at the center of Future Link™, contribute to safety and security, and expand its business.

Future Link™ is the trademark of FUJITSU TEN LIMITED.

Profiles of Writers



Hiroaki KAWANISHI
Component Development Dept.
ITS Engineering Group.

Ryuichi MORIMOTO
Component Development Dept.
ITS Engineering Group.

Shingo TAGUCHI
Team Leader of Component Development Dept.
ITS Engineering Group.