Development of Car Navigation System Featuring HD Quality Image

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Abstract

Display size of car navigation has been increased in size to 7-inches, 8-inches, 9-inches and 10-inches. However, WVGA (Wide Video Graphics Array) of 800 dots in horizontal direction and 480 dots in vertical direction is main stream for display resolution.

On the other hand, smartphone and tablet PC adopt high resolution display featuring HD (High Definition) of 1280 dots in horizontal direction and 720 dots in vertical direction or FHD (Full High Definition) of 1920 dots in horizontal direction and 1080 dots in vertical direction in accordance with increasing display size. Thus the demands for high quality / high definition image display for display of car navigation rise.

This time we have developed new in-vehicle system which responds to high quality / high definition image display in accordance with the demands of market. This system consists of car navigation centered in this system and peripheral devices such as monitor camera for surroundings and rear seat display. We would like to introduce it.

1 Introduction

Recently, display size of car navigation system (hereinafter referred to as car navigation) has been increased in size to 7-inches, 8-inches, 9-inches and 10-inche. However, WVGA (Wide Video Graphics Array) of 800 dots in horizontal direction and 480 dots in vertical direction has been continuously adopted as display resolution.

On the other hand, as for consumer electronics products, smartphone and tablet PC adopt high-resolution display featuring HD (High Definition) which has 1280 dots in horizontal direction and 720 dots in vertical direction or FHD (Full High Definition) which has 1920 dots in horizontal direction and 1080 dots in vertical direction in accordance with increasing display size. Thus the demands for high definition / high quality of display image increases.

FUJITSU TEN has commercialized in-vehicle systems such as car navigation, rear camera, surroundings monitoring camera and Rear Seat Display (hereinafter referred to as RSE). At this time we have reviewed in-vehicle system to improve display resolution of car navigation and RSE from WVGA to HD in accordance with the demand of market, and then we have developed a new in-vehicle system which is capable of displaying images with high quality / high definition. This paper introduces HD supported in-vehicle system with high quality / high definition.

2 Outline of System

Fig. 1 shows the entire structure of conventional in-vehicle system.

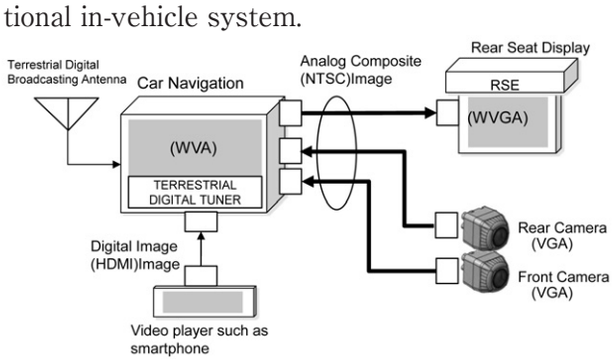

Fig. 1 Conventional In-vehicle System Structure

As the display used in car navigation was WVGA with 0.38 megapixels, low-pixel (about 0.3 megapixel sensors of which image data can be transmitted by NTSC (National Television System Committee) method was used as surroundings monitoring camera like rear camera. Also analog composite type NTSC method was used for video transmission method between car navigation and RSE. HD supported in-vehicle system structure is shown in **Fig. 2**.

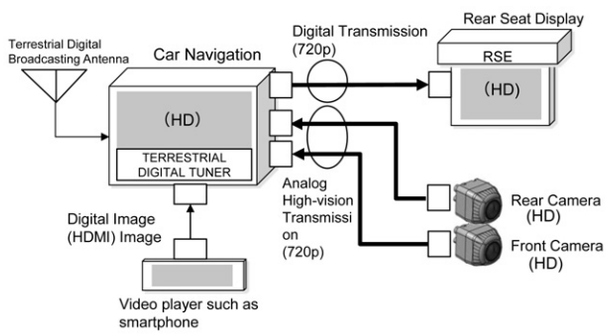

Fig. 2 HD supported in-vehicle system

Because pixel number of HD display are about 0.92 megapixel, conventional analog composite type NTSC method is not enough for image transmission among car navigation, surroundings monitoring camera and RSE, we have adopted a new method capable of 720p(1) transmission in accordance with each device. We will introduce the detailed contents in the next sections by structure part.

3 Car Navigation

3.1 Outline

When we adopt large HD display, the map screen and menu screen which were conventionally displayed on a WVGA display are not drawn clearly on a HD display because of enlarged drawing. Therefore we have newly designed images which respond to 1280 dots in horizontal direction and 720 dots in vertical direction, and

*(1) This number shows the number of effective vertical resolution, and the number of 720 means 720 lines of effective vertical resolution. Alphabet means scanning mode, and "p" is progressive scan and "i" is interlace scan.
For reference, 480i means the image which has 480 lines of effective vertical resolution with interlace scan.

realized high resolution. As a result the drawing with high definition and fine gradation becomes possible. **Fig. 3** shows the contents of display.

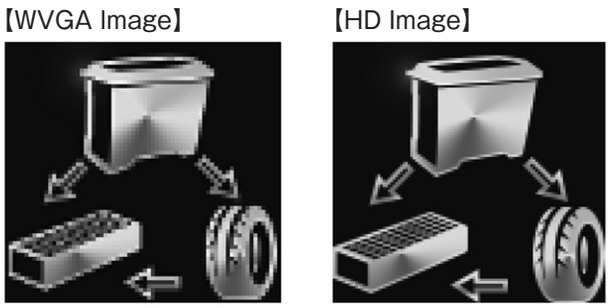

Fig. 3 Difference in Resolution between WVGA Drawing and HD Drawing

As for the image source such as TV, video file image on SD card and USB memory, and HDMI, the image with high definition feeling could be displayed on the display by digital 720p transmission through the route in car navigation from the input side to the display. Also the system is designed for responding to 720p transmission of GVIF™ (Gigabit Video InterFace) of image output to RSE.

3.2 System structure

We have built the system for the image quality in order not to deteriorate on the occasion of HD. The image system structure is shown in **Fig. 4**.

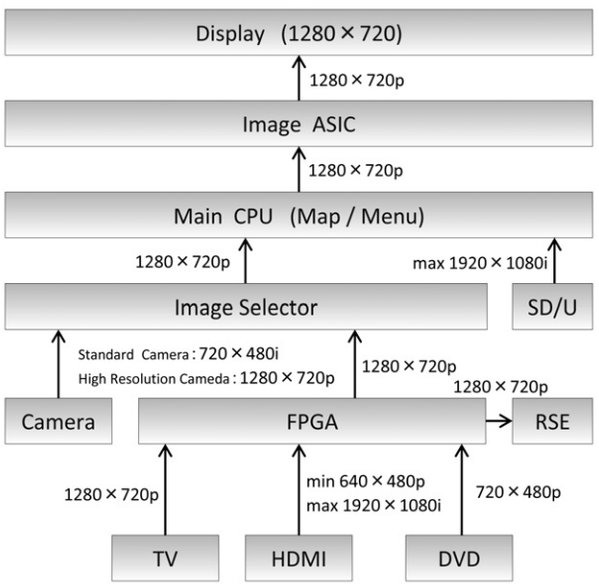

Fig. 4 Image System Structure

Resolution and frame rate are different depending on each image source, then we needed to integrate those. FPGA, image selector and main CPU shown in **Fig. 4** execute the integration above and image switching for each image source.

Regarding resolution, as original image data of DVD has 720 dots in horizontal direction and 480 dots in vertical direction, the performance of HD display cannot be better utilized only with simple enlargement process.

Instead of enlargement processing by simple stretching, we realized the image with higher feeling than the original image in resolution to magnify an image with interpolation considering neighbor pixel data in the above FPGA. We magnify images from other source by interpolation like the above when they have lower resolution than HD.

The image ASIC described in **Fig. 4** realized high image quality by performing optimum correction of images from each image source independently, which was not possible in the past.

Although we tried to build optimum system structure supporting HD only with general purpose IC in the step of early development, there were two big issues.

One was the difficulty of mounting on PCB because large scale circuit structure is needed, which consists of; two types of video processing ICs, two types of video selectors and three types of video distribution circuits.

The other is deterioration of image quality because all of general purpose IC cannot digitally transmit data, which is partially transmitted with analog system. We have studied development of ASIC in which all functions are integrated to solve these issues.

However, due to the tightened development schedule and large development cost, we have adopted FPGA instead of ASIC. As a result, we have materialized the image system structure supporting HD while considerably shortening the development period, reducing the development cost, and integrating all of necessary functions.

4 Real Seat Display

4.1 Outline

In order to respond to high resolution like car navigation, we have adopted 720p transmission method of GVIF which is capable of HD of 1280 dots in horizontal direction and 720 dots in vertical direction, and of HD transmission from car navigation. Next section describes a study report for adopting 720p transmission method of GVIF.

4.2 GVIF transmission between car navigation and RSE

High speed performance of information transmission is needed to realize 720p transmission of GVIF in comparison with conventional 480p transmission.

Under the in-vehicle environment, we must consider many factors; temperature environment like low temperature / high temperature; the influence such as bending / tying of transmission cables while being installed at sales shop; and connection of sub-wire (extension code), then we must verify the robustness for increasing transmission speed. These external factors affect skew amount between differential signals (deviation amount between signals) and attenuation of signal level in GVIF transmission. This time, we work out the worst case values of skew amount and attenuation on paper considering the external factors under the in-vehicle environment to evaluate feasibility of 720p transmission of GVIF, and confirmed that the worst values satisfy the specification of receiving (Rx) IC of GVIF.

As GVIF transmission includes an equalizer function (waveform correction function) we finally need verification by using actual equipment in order to confirm the feasibility including that function. To determine the limit of skew amount and attenuation for feasibility of GVIF transmission, we prepared several transmission cables with various values of skew amount and attenuation, and then we evaluated the feasibility by using the actual equipment while changing values of skew amount and attenuation by the combination of those cables.

As a result, the worst case values of skew amount and attenuation calculated on paper were within the range of proper operation, thus we have confirmed with the actual equipment there is no problem even for 720p transmission.

5 Camera

5.1 Issues of Development

In accordance with the increasing display size and high resolution of car navigation, requirement of high resolution for the rear and front camera of which images are indicated on a car navigation screen as driving assistance increases. However, we needed to solve the following issues to succeed the development of HD supported camera.

Issue① HD transmission with conventional wire harness

As for the transmission route of NTSC camera, the wire harness called pre-wired harness was installed in advance in a vehicle. This wire is conventionally used for easy installation. Also in this system we need to use this pre-wired harness. And existing NTSC transmission method cannot transmit 720p format data which is the maximum transmission amount of HD because the maximum transmission amount of NTSC is 480i. Therefore we had to adopt other transmission method than NTSC.

Issue② Reduction of the number of camera interface

There are four types of cameras connecting to car navigation as the following.

・480i rear camera
・480i corner camera
・720p rear camera
・720p front camera

When we newly create the interface of HD camera which we will newly develop, car navigation needs four interfaces at a maximum, which causes increase of system cost due to connecting cameras.

Issue③ Improvement of light sensitivity

To increase the light sensitivity which is basic performance of a camera, the sensor size needs to be increased. This leads to larger outer size of the camera, which may cause that the camera cannot be installed to vehicle. Then we must increase the light sensitivity with conventional camera size.

5.2 Adoption of Analog HD Transmission

As the result of investigation of method which can transmit HD through pre-wired harness, we focused on analog HD transmission method "HD-TVI", which has many adoption achievements for monitoring camera. Camera system structure using HD-TVI is shown in **Fig. 5**.

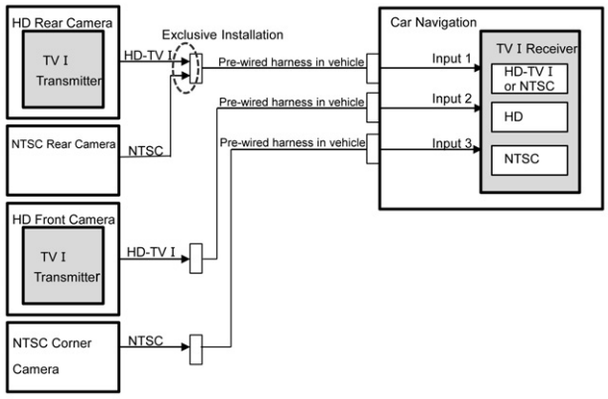

Fig. 5 Camera System Structure

HD-TVI transmission method which consists of dedicated transmitter (for camera) and dedicated receiver (for car navigation) has advantages of adoption.

Fig. 6 NTSC Camera Image

Fig. 7 High Resolution Camera Image

・HD transmission through pre-wired harness is possible
・Receiver accepts NTSC decode and multi-channel input

Therefore we have solved the previous issues ①, ② by adopting this method. We consolidate the interfaces to three by HD transmission through pre-wired harness in- vehicle, integration of rear camera data transmission route, and one-chip receiver so that we have realized the system with minimum cost,

For reference, NTSC camera image is shown in **Fig. 6** and high resolution camera image by HD-TVI is shown in **Fig. 7**. We have conformed that high resolution camera image clearly indicates the neighboring vehicle and road situation.

5.3 Light sensitivity

We have determined that the shutter speed is set to 30 fps at a maximum, and to adopt high sensitivity sensor of which sensitivity is equivalent to or more than that of VGA camera with the same size in order to improve the light sensitivity of the small camera with high resolution.

However, as the frame rate of car navigation display is 60fps, conversion of frame rate is needed from 30fps to 60fps by camera or car navigation. In case that camera has conversion function of frame rate, increase of current consumption, increase of heating value, and increase of cost due to additional memory are concerned. We allocated the conversion function to car navigation, and integrated the functions into conversion function block of frame rate for other source and the above block.

We have solved the issue ③ by this allocation of functions and have realized the camera with small size/ high definition / high sensitivity / low power consumption.

6 Conclusion

Through this development, we have performed a review of the whole system based upon the theme "realization of high quality / high definition image display" centering car navigation besides peripheral device. Also the system can clearly display the individual visual contents and express the performance of display to customers by adopting a new technology.

Developed In-vehicle system which can display the high quality / high definition images was adopted as a dealer option of 2016 model vehicle of TOYOTA Motor Corporation. We would like to appreciate the people concerned who offered great cooperation for the installation to each vehicle and confirmation of wiring specification.

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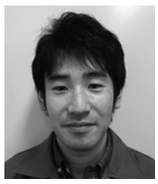

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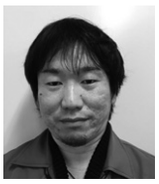

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