Development of ASIC for VGA Display

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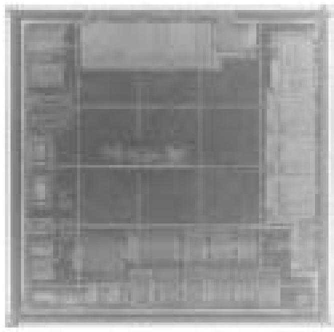


With the widespread distribution of navigation equipment and portable phones, a variety of information has come to be available though an internet connection, even in cars. The recent distribution of DVD's have also greatly expanded the amount of available information, and it is now important to present information to the user in a user-friendly format.

Accordingly, the display device has been replaced with a high resolution VGA (Video Graphics Array), and a touch panel has been implemented as an input device. Now it is possible to operate just by touching the displayed image on the screen directly.

Here we introduce an IC that can display TV screens, while allowing compatibility with touch panel operation and high resolution VGA LCD display devices.

1 Introduction

We have been working to develop a vehicular receiver which can receive stable transmissions even under environmental conditions with electric field fluctuations or weak electric field characteristics. This IC was developed with careful consideration for a circuit design that would remain stable under weak/fluctuating electric field conditions. The following are features that were gained as a result of the development:

①High resolution: Video Signal → VGA conversion (Y/C separation, progressive scan conversion)

②2 screen display: Navigation screen + TV screen

③Multi TV channel display: 8 channel still image display

④VNR Feature: A stable TV reception was made possible even in weak electric field conditions. The following features were also made possible by making the circuits fully digital.

⑤Omission of the LCD display panel adjustment process on the manufacturing line.

⑥Adjustment of picture quality to match individual vehicles, by utilizing a ROM table prepared per vehicle type.

2 VGA Display ASIC Overview

2.1 VGA Display Section Configuration

Fig. 1 shows the configuration of the 2002 model, VGA panel compatible AVN display section (02VGA-AVN display).

The display section consists of the panel circuit board and the TFT panel (Including the backlight). The image signals listed below are sent to the panel circuit board, and signal processing (such as RGB signal conversion and screen enlargement/reduction) is performed to drive the LCD display. The image is then displayed on the screen.

<Image Signal Input to the Display Section>

①Composite Video Signals

TV, VTR, DVD, Video, Etc.

②EGA-RGB Signals (Resolution: 400×234 / 480×234 dots)

EGA Navigation, Camera, Etc.

③WVGA-RGB Signals (Resolution: 800×480 dots)

WVGA Navigation

2.2 ASIC Built-in Features

As can be seen in fig. 1, this ASIC is a semi custom LSI, combining the TV signal processing system and TFT panel control. A large cost reduction and miniaturization is achieved by digitizing the composite video signal that is demodulated and amplified at the TV tuner, and bY/Changing the succeeding TV Signal processing system to LSI (converting to a digital system).

This ASIC also includes our vehicular TV reception improvement technology, the VNR (Video Noise Reducer). The main features of this ASIC, such as the decoder and screen enlargement/reduction processing and the VNR process, has many circuits in common (frame memory, Y/C separation, clock generator, etc.) and we were able to integrate the 5 chips which comprised the VNR until now, into one ASIC chip. By sharing the memory for the image expansion/reduction processing section with the frame memory of the VNR single feature (which was a large portion of the cost for VNR), a cost increases was avoided.

The main built-in circuits and basic specifications of this ASIC are shown in Table 1.

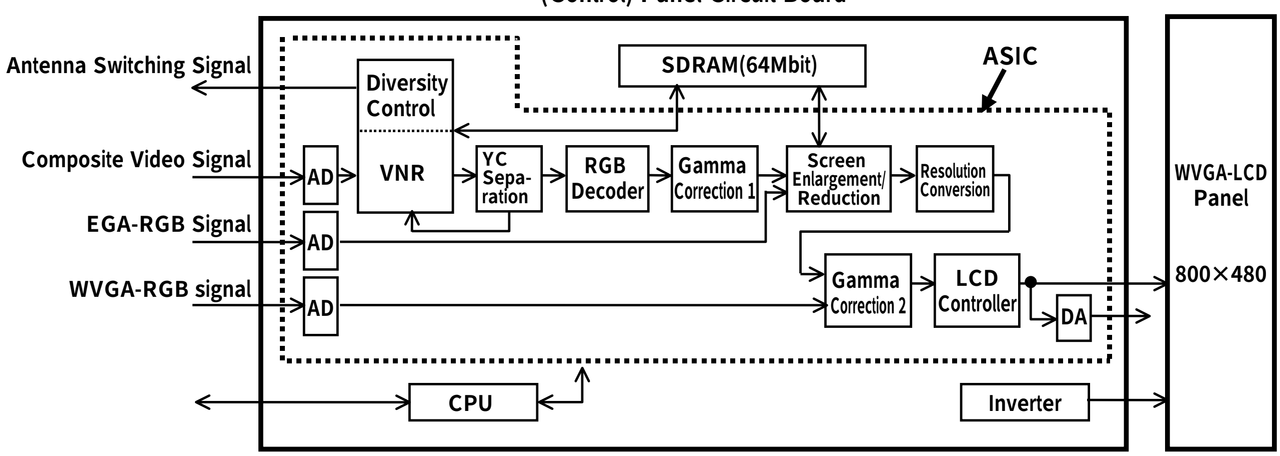


Fig.1 2002 YEAR MODEL VGA-AVN Display Section Configuration

Table 1 Main Built-in Circuits and basic specifications of the ASIC.

Internal Circuit	Basic Specifications
Input Image Source	TV: Composite Video Signal (NTSC/PAL compatible) Navigation: EGA-RGB (480x234/400x234) WVGA-RGB (800x480)
Y/C Separation	3 Line Applicable Digital Com (NTSC/PAL compatible)
RGB Decoder	NTSC/PAL Compatible Image Adjustment ・Variable ACC Characteristics (64 levels) ・Color Killer Adjustment (64 levels) ・Picture Adjustment (64 levels) ・Tint Adjustment (256 levels) ・Color Adjustment (256 levels, Cb/Cr independent) ・Contrast Adjustment (256 levels) ・Brightness Adjustment (256 levels)
Gamma Correction Circuit	2 System (TV, TFT Panel)
Screen Enlargement/ Reduction	Enlargement/Reduction control by Primary Interpolation (Bilinear Method) Optional enlargement/reduction rate, display position setting
TFT Controller with Image Resolution conversion	Can display on LCD panels with the following resolutions (Compatible with both Analog/Digital IF) ・EGA1 (480×234) ・EGA2 (400×234) ・WVGA (800×480)
Diversity Antenna Switching Control	Optimum control by image deterioration detection
VNR Circuit	Mobile TV Reception Image Improvement Process (NTSC only)

3 Description of Circuit Blocks

3.1 VNR (Video Noise Reducer)

The largest problem in vehicular TV systems is the deterioration of image quality due to drastic fluctuations in electrical fields, caused by the mobile environment. The VNR is a vehicular digital signal processing circuit for reducing this image deterioration.

The basic principle of this image improvement process is adaptive control, through a recursive filter using frame memory. A recursive filter configuration using frame memory is shown in figure 2.

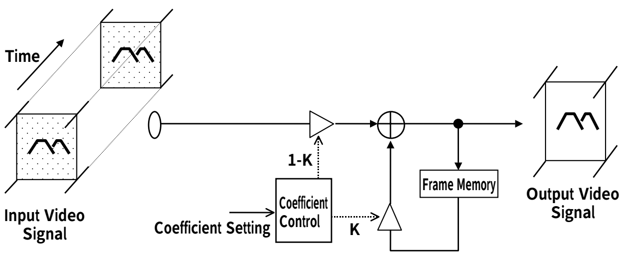


Fig.2 Recursive Type Filter Configuration using Frame Memory

As can be seen in Fig. 3, the theoretical S/N improvement is approximately 20dB.

The circuit configuration is shown in fig. 4.

The composite video signal from the tuner module is applied to the frame recursive type filter. The filter

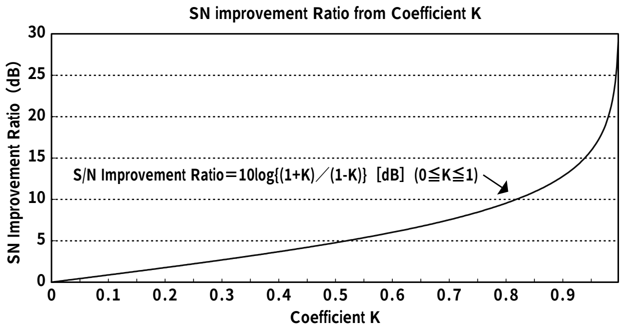


Fig.3 Theoretical S/N Improvement Ratio

characteristic coefficients are stored in a dedicated memory, and are adaptively controlled using an S level which shows the electric field condition.

Sharp changes in electric fields and multi-pass are also detected, to enhance the noise reduction effect.

As can be seen in Fig.5, the color burst signal fluctuations, synchronization signal distortions and the amount of changes in S level are detected in the input video signal by this image deterioration detection circuit. By detecting all changes in the reception environment and performing adaptive control of the filter coefficient, a very stable TV image can be displayed even under vehicular reception conditions.

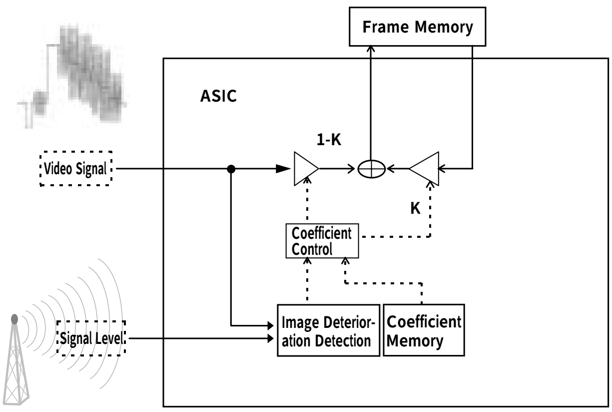


Fig.4 VNR Circuit Configuration

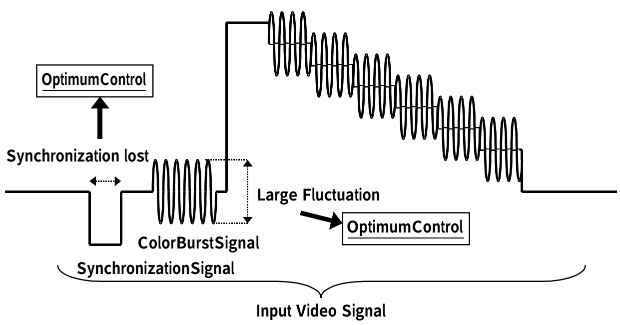
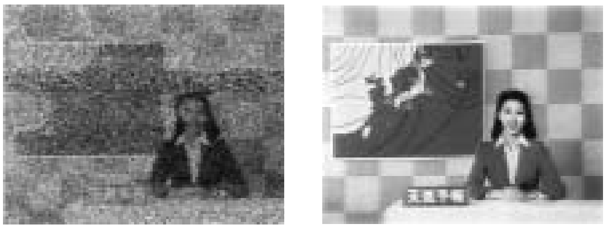


Fig.5 Applicable Control to Video Signals

The image quality improvement effects of the VNR is shown in Fig. 6.



Without VNR Processing With VNR Processing

Fig.6 Graphics Quality Improvement Effects from VNR

3.2 Y/C Separation Circuit

The Y/C separation circuit is a circuit which separates the brightness signal and the color signal from the composite video signal. The separation accuracy is what determines the quality of the picture.

In Y/C separation circuits utilized in conventional models, the color signal is extracted by BPF, and the brightness signal is extracted by LPF or BPF. This has a bad separation accuracy, and suffers from cross color interference (An interference where monochrome images are colored with rainbow-like colors.) where the brightness signal is extracted as a color signal.

The Y/C separation circuit of this ASIC utilizes a digital com filter, and is successful in greatly reducing cross color interference in comparison to conventional models.

Correlation for the color signal between adjacent dots are detected, and the characteristics of the BPF for color signal extraction are changed adaptively in accordance. This adaptive filter reduces the horizontal dot interference, in which the color signal is extracted as a brightness signal, and white or black dots appear on the outlines of images.

The configuration of the Y/C separation circuit for this ASIC is shown in Fig. 7.

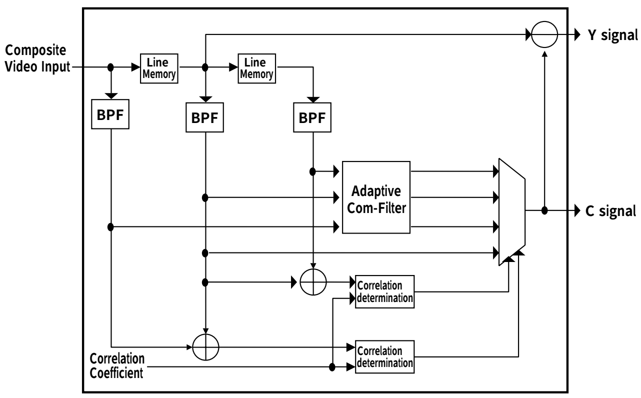


Fig.7 Y/C Separation Circuit Configuration

Table 2 shows the improvement effect in comparison to our existing models. The evaluation was performed through an 7 level subjective evaluation.

Table 2 Improvement Effects of the 2 Dimensional Y/C Separation.

Item/Improvement Effect	Our Existing Models	ASIC Equipped Model
Horizontal Resolution	4	5
Vertical Resolution	4	5
Cross Color Interference	4	5
Dot Interference	4	5

3.3 RGB Decoder

3.3.1 Basic Process

The color signal that has been Y/C separated is applied to the ACC (Automatic Color Control) circuit, and the color burst signal amplitude (the base for demodulating the color information) is detected. An amplification rate is determined for this signal so that the amplitude of the color burst signal is kept at a steady level, and amplitude control of the color signal is performed. The burst signal section created by this ACC control circuit is extracted, and a continuous color demodulation standard signal is created. The base color RGB signal is recovered from this standard signal.

The block diagram for the RGB decoder section is shown in Fig. 8.

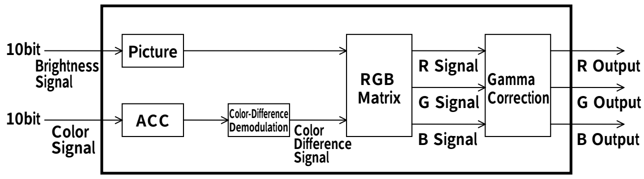


Fig.8 RGB Decoder

3.3.2 Measures for Weak Electrical Fields

Vehicle mounted TV systems receiving ground based TV broadcast signals are often subject to conditions where weak electric fields occur. To deal with the issue of this weak electric field, a specialized filtering process designed for vehicular use is provided in ACC circuit of this ASIC, to accurately detect the color burst phase. In addition, an 8 bit A/D converter had been used for the composite video signal in conventional models. For this model, a 10 bit A/D converter has been utilized to improve image quality.

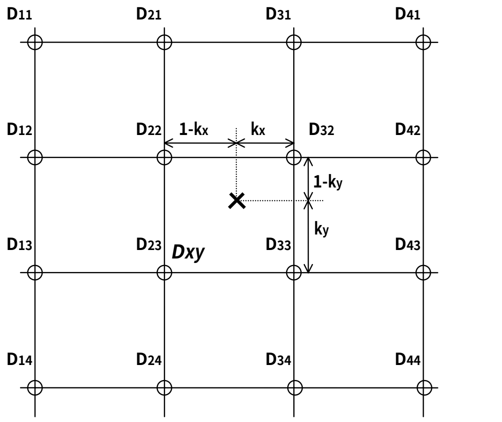
3.4 Screen Enlargement/Reduction

3.4.1 Interpolation Method

When enlarging or reducing an image, if there is no corresponding pixel, a process called interpolation is performed to create this pixel. In this ASIC, an interpolation method called the bilinear method is utilized. By judging the importance and taking the average of the pixels surrounding the pixel to be created, a smooth enlargement/reduction of the screen is made possible.

(Refer to Fig. 9. The "x" is the target of the interpolation.)

The block diagram of the screen enlargement/reduction section of this ASIC is shown in Fig. 10.



The Coefficient k is a ratio of 2 points in relation to position "X"

$Dx = D_{22} \times (1-kx) + D_{32} \times kx$

$Dy = D_{32} \times (1-ky) + D_{33} \times ky$

Fig.9 Interpolation Method

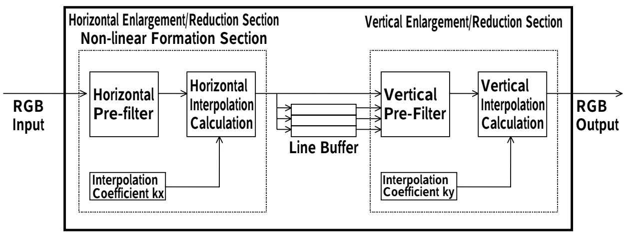


Fig.10 Screen Enlargement/Reduction Section

As can be seen in the figure, by configuring the enlargement/reduction process of the horizontal and vertical directions separately, a screen enlargement or reduction with a desired aspect ratio (vertical/horizontal ratio) is made possible.

3.4.2 Image Display

As mentioned earlier, horizontal and vertical directions can be enlarged or reduced independently, and the enlargement/reduction ratio can be set from 1.0x to 8.0x.

Also, because it is possible to display multiple images (no real restrictions on the number of images) in desired locations, various graphics display formats (Fig. 11, multi-screen) are made possible. It is also possible to display images within images (PIP(Picture In Picture)) (Fig.12 PIP Display).

Fig.11 Multi-Screen

Fig.12 PIP (Picture in picture) Display

3.5 Resolution Conversion

To run display mediums, there is a interlaced method and a progressive method. Current LCD panels used in vehicles use interlaced EGA panels, or a progressive compatible VGA panel.

This ASIC is compatible with both display methods.

3.6 LCD Panel Interface

As the movement to digitalization has continued in recent years, more and more LCD panels are now compatible with digital interfaces. (Digital IF). However the conventional analog interface (Analog IF) TFT panels are still common, so the LCD panel interface for this ASIC was made compatible with both digital IF and analog IF.

4 Physical Specifications of the ASIC

The physical specifications of this ASIC is shown in Table 3.

Table 3 ASIC Physical Specifications.

Built-in A/D Converter	10bit, 20MS/s×1 10bit, 1MS/s×1 8bit, 50MS/s×6
Built-in D/A Converter	8bit, 50MS/s×3
Process	0.35μm Embedded Array
Package	LQFP-256 (0.4mm pitch: Plastic Package)
Power Supply Voltage	5V, 3.3V

5 Merits of Changing to LSI

The merits involved in changing to LSI are described below:

(1)Cost Reduction

Reduction Ratio From Multi-purpose LSI configuration: ▲67%

(2)Miniaturization

Reduction Ratio From Multi-purpose LSI configuration: 1/5

TV signal processing, screen control and display control circuits can now be mounted in the 02VGA-AVN display section panel circuit board (80mm x 150mm)

Fig. 13 shows the panel circuit board equipped with this ASIC

(3)No Adjustments Required due to the Digitalization of the TV Signal Processing Section.

(4)By internalizing 2 gamma correction systems for the TV signal and the Navigation Signal, the display image from the image source is accurately reproduced.

(5)Compatible with PAL even without changes to external parts.

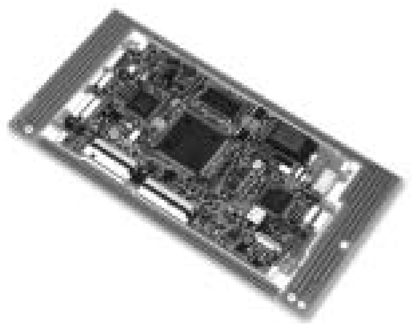


Fig.13 Control Panel Circuit Board Equipped with our new ASIC

6 Performance Comparison with Products of other Companies

Tables 4 and 5 show the comparison of this ASIC built-in circuit and the TV reception performance, with VGA panel equipped products from other companies.

An increased number of features and high performance as a vehicle mounted TV reception LSI was gained, by onverting the vehicular TV signal processing circuit to LSI as described in chapter 3.

7 Conclusion

This IC completes the digitalization of the circuitry involved in converting TV tuner output video signals to RGB output for LCD display devices, that we have been working on for the past few years. Also, features such as multi channel display and navigation/TV dual screen displays have been made possible. This IC was able to produce excellent results in cost/quality/performance/miniaturization/and development time. We hope to continue developing high performance and low cost IC products in the future.

Table 4 Comparison with products of other companies (ASIC Internal Circuit).

Built-in Circuit	ASIC Equipped in Company 'A' Product	This ASIC
YC Separation	×	○
RGB Decoder	×	○
Single Screen Control	○	○
Multiple Screen Control	×	○
PIP	×	○
IP Conversion	○	○
Compatible TFT Panel	Digital 6 bit RGB	Digital 6 bit RGB (EGA/WVGA) Analog RGB (EGA/WVGA)

Table 5 Comparison with products of other companies (TV Reception Performance).

※with VNR Feature OFF

Principal Evaluation	Company 'A' Product	ASIC Equipped System	Effectiveness
Static Weak Electric Field Characteristics (Synchronization Disruption)	Vertical synchronization disrupted at antenna input Level of 27dBuV or less.	No synchronization disruption until the display image cannot be viewed.	◎
Static Weak Electric Field Characteristics (Color Loss Sensitivity)	Antenna input Level 23 dBuV	Antenna Input Level 23dBuV	○
Dynamic Electric Field Fluctuation Characteristics (Relative Subjectivity Evaluation)	—	Less synchronization disruption due to electrical field fluctuations, in comparison to the product from company 'A'	◎

Reference

・The Institute of Image Information and Television Engineers : "Standard Image"

Profiles of Writers

Atsushi Mino

Entered the company in 2001. Since then, has pursued development of TV-related signal processing LSI. Currently in the LSI Research and Development Department.

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