

## ELECTRONIC IMAGE STABILIZER FOR VIDEO CAMERA USE

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### ABSTRACT

A compact electronic image stabilizer was realized by developing two main techniques: (1) scanning area selection of the imager, and (2) motion vector detection. The stabilization rate we obtained is 18 dB at 1 Hz. This system is very suitable for recent compact video cameras, but the stabilization rate becomes poor at high frequency. So, an advanced system was also designed.

### INTRODUCTION

Recent video cameras for consumer use are tending toward compactness and high zoom ratio. So the reproduced images recorded by those cameras are apt to swing even if users handle the video cameras carefully. As the unexpected image swing degrades the quality of reproduced image so much, we tried to stabilize the image swing by an electronic compact system.

In order to realize the system, the methods for image swing suppression and motion detection is required as shown in Table 1. The methods we examined for image swing suppression are "imager scanning", "memory read/write", and "movable lens block" [1]. And the methods for motion detection are "signal correlation", and "motion sensor". According to Table 1, 6 kinds of systems (A~F) are available for the image stabilizer. System A is most compact because it is composed of electronic circuits which are able to be integrated into an LSI. System F is not suitable for the compact video cameras because it needs the movable mechanism and motion sensor in addition to an LSI. The order of compactness is A,B,C,D,E,F.

In order to compose the image stabilizer in a compact system, system A was chosen and two main techniques mentioned above were developed.

Table 1 Necessary Main Parts for Respective Method

	Method	Image swing suppression		
		Imager scanning	Memory R/W	Movable lens block
Motion	Signal correlation	Base* (A)	+Memory (B)	+Movable Mechanism (E)
detection	Motion sensor	+Motion sensor (C)	+Motion sensor (D)	+Movable Mechanism +Motion sensor (F)

\* Custom LSI only

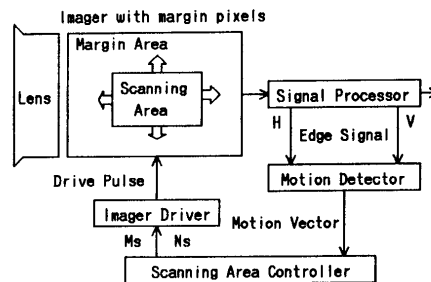


Fig.1 System Block Diagram

### TOTAL SYSTEM

Fig.1 shows the developed system. The imager has margin pixels in addition to scanning pixels.

Both pixels are available for photo-electron conversion. The charge accumulated in scanning pixels is read out, and the charge accumulated in margin pixels is swept out. The scanning area which contains the scanning pixels is movable in horizontal and vertical direction by means of drive pulse control. In addition that, the image swing is detected by the motion detector in the form of motion vector which is composed of horizontal and vertical motion vector.

According to the detected motion vector, the scanning area controller controls the imager driver, and the scanning area moves so as to offset the image swing.

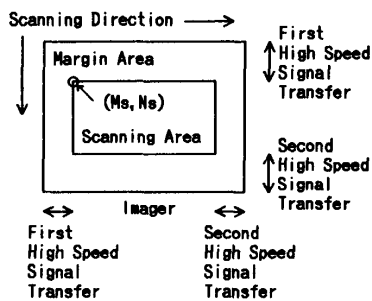


Fig. 2 Imager Signal Readout

SCANNING AREA SELECTION

A popular method to move a displayed video image is memory read/write control. But that system is not suitable for the compact video camera because it needs the field memory (about 1.5 Mbits to memorize one field), A/D, and D/A. From a standpoint to pursue the compactness, scanning area selection of the imager was contrived as shown in Fig.2. The signal charge accumulated in margin area is swept out quickly in the horizontal and vertical blanking period by the high speed signal transfer. The signal charge in scanning area is read out normally in the horizontal and vertical scanning period.

The high speed signal transfer, mentioned above, is possible by changing the frequency of the drive pulse for high frequency, and the starting pixel to be read out normally is selectable by changing the number of high frequency drive pulse.

The margin area is able to be prepared by developing an imager which has margin pixels, and also can be prepared by using the electronic zoom.

$M_s$  and  $N_s$  shown in Fig.1,2 are the address of the starting pixel in vertical and horizontal direction respectively, and  $N_s$  is shown as follows.

$$N_s = n+1 \quad \dots (1)$$

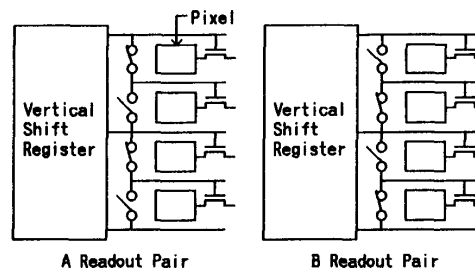


Fig. 3 Signal Transfer (MOS Imager)

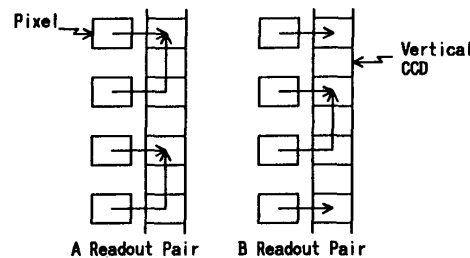


Fig. 4 Signal Transfer (CCD Imager)

Table 2 Scanning Area Selection

Vertical location of scanning area	Odd field		Even field		Address of the starting pixel Ms
	Number of drive pulse*	Readout pair	Number of drive pulse*	Readout pair	
:	:	:	:	:	:
Up by 3-pixel pitch	m-2	B	m-1	A	2m-3
Up by 2-pixel pitch	m-1	A	m-1	B	2m-2
Up by 1-pixel pitch	m-1	B	m	A	2m-1
(Starting point)	m	A	m	B	2m
Down by 1-pixel pitch	m	B	m+1	A	2m+1
Down by 2-pixel pitch	m+1	A	m+1	B	2m+2
Down by 3-pixel pitch	m+1	B	m+2	A	2m+3
:	:	:	:	:	:

\* Vertical high frequency drive pulse

where, n is the number of horizontal high frequency drive pulse at the first high speed signal transfer. So the scanning area is selectable by one-pixel pitch in the horizontal direction. In the vertical direction, as the pixels are scanned by two-pixel pitch, the image movement by scanning area selection becomes stiff if the scan method mentioned above was used. The scanning area becomes selectable by one-pixel pitch even in the vertical direction by using the following selection, and the image movement becomes smooth.

$$M_s = 2m + (F - P) \quad \dots (2)$$

$$F = \begin{cases} 1: \text{odd field} \\ 0: \text{even field} \end{cases}$$

$$P = \begin{cases} 1: \text{A readout pair} \\ 0: \text{B readout pair} \end{cases}$$

where, m is the number of vertical high frequency drive pulse at the first high speed signal transfer. P symbolizes the readout pairs shown in Fig.3 and Fig.4, and A,B readout pairs are selectable by controlling the normal drive pulse.

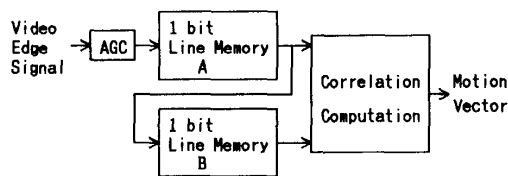


Fig.5 Motion Detector

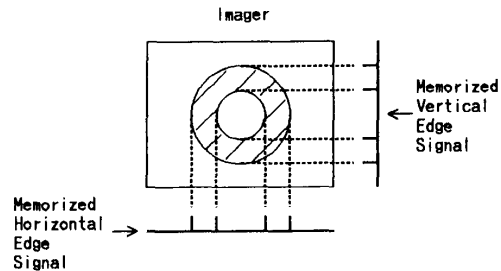


Fig.6 Signal Projection

This scanning area selection is based on the interlaced scanning of the imager and the display. The concrete combination of the readout pair and the number of vertical high frequency drive pulse is shown in Table 2.

MOTION VECTOR DETECTION

Fig.5 shows our contrived motion detection. The horizontal and vertical video edge signals are memorized in the one bit line memory A separately so as to project a two dimensional image on one dimensional reduced edge data as shown in Fig.6. The reduced edge data is delayed for one field period by the line memory B, and the motion vector is detected by computing the correlation between non-delayed edge data and delayed edge data.

By setting the sampling frequency of the memory A,B equal to that of the imager scanning, the horizontal motion vector is detect-

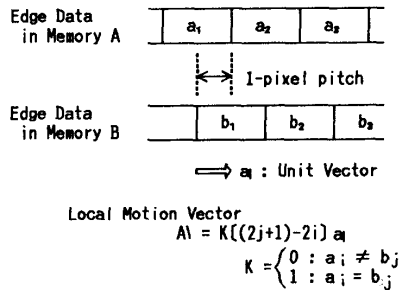


Fig.7 Correlation Computation for Motion Vector

able by one-pixel pitch. The vertical motion vector is also detectable by one-pixel pitch by taking the imager scanning, mentioned above, into consideration as shown in Fig.7.

There is a spatial shift by one-pixel pitch between the edge data in memory A and B according to the interlaced scanning of the imager. So, as for one edge data, the local motion vector is obtained by the correlation computation shown in Fig.7, and general motion vector is calculated by investigating the distribution of the local motion vectors.

### RESULT

Several image stabilizers were manufactured using an MOS and a CCD imagers. The MOS imager is suitable for the scanning area selection because the pixels are scanned by the shift registers[2], but the MOS imager is not suitable for the image stabilizer because the pixels are scanned in sequence. All pixels are scanned at different time respectively, so the reproduced images are bent with the scanning area selection.

The specification of the CCD imager we used is shown in Table 3, and the image stabilization rate obtained by the trial video camera is shown in Fig.8. The obtained stabilization rate is 18 dB, 9 dB, 3 dB at 1 Hz, 3Hz, 6Hz respectively.

Table 3 Specification of Used Imager

Number of Pixels	Scanning Area	660 (H) × 485 (V)
	Margin Area	135 (H) × 99 (V)
Imager Type	IL-CCD	

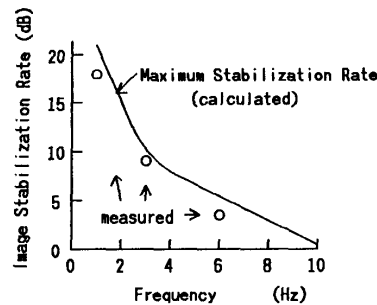


Fig.8 Image Stabilization Rate

The system shown in Fig.1 has feedback loop, and when the movement of the images is detected, the movement has already been displayed. So the stabilization rate becomes poor when the frequency of the image swing becomes high. In order to improve the frequency response, an advanced system was also designed.

### IMPROVEMENT OF STABILIZATION RATE

The advanced system is shown in Fig.9. In addition to the stabilization by the feedback loop, the feedforward loop stabilizes the image swing. ( we call this system Double Image Stabilizer; DIS ) The signals from the scanning area are memorized in the buffer memory, and the signals from the displaying area are read out. The displaying area is selectable by controlling the memory read/write address.

In the DIS, the heavy image swing is stabilized roughly by the feedback loop, and the remained image swing is stabilized correctly by the feedforward loop. The frequency of the heavy image swing is generally low enough for the feedback loop to stabilize the image. And

the amplitude of the remained image swing is small enough for the feedforward loop to detect the motion vectors by the correlation computation with not so large circuits. The reason of that is as follows. The local motion vectors are able to be obtained by the correlation computation in a small area because the amplitude of the remained image swing is small.

Because the movement of the images is also stabilized by the feedforward loop, the movement of the images is not displayed before the motion detection. So the stabilization rate at high frequency is to be improved.

The timing chart of the memory control is shown in Fig.10. The delay time by the buffer memory is selectable from 1 H ( H : horizontal period ) to 1 field period, and by that time, the motion detector completes the correlation computation for the feedforward loop.

That motion detection becomes to able to detect the whole image movement and the stabilizable amplitude becomes to increase according as the delay time increases, but at the same time, the required capacity of the buffer memory increases. Taking the efficiency of the image stabilization and the scale of the system into consideration, the delay time and the capacity of the buffer memory are set to be equal to the vertical blanking period. So, about 20 line memories are required for the buffer memory.

Using the recent submicron process for an LSI, that line memories are able to be integrated into an LSI chip with other circuits - signal processor or memory controller and so on -, so the system maintains the compactness.

### CONCLUSION

A compact electronic image stabilizer was realized. We manufactured several video cameras by way of trial and exhibited a compact video camera at the Japan Electronics Show '89.

The obtained stabilization rate is 18 dB at 1 Hz. The developed system is very suitable for the compact video cameras, but the stabilization rate becomes poor at high frequency. The frequency response is to be improved by the DIS which has the feedforward control, and the compactness of the system is to be maintained.

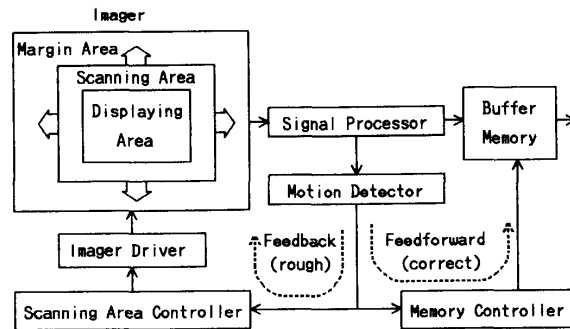


Fig.9 Double Image Stabilizer (DIS) System

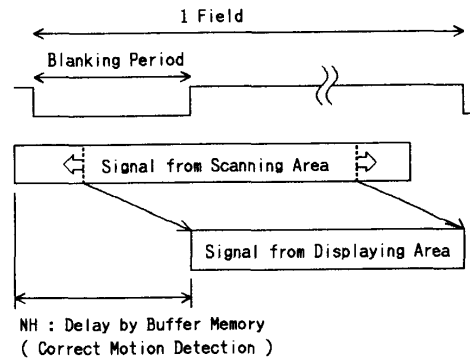


Fig.10 Displaying Area Control by Buffer Memory

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- [2] Kinugasa et al., "An Electronic Variable-Shutter System in Video Camera Use", IEEE Trans. on c. e., vol. CE-33, Aug. 1987

BIOGRAPHIES

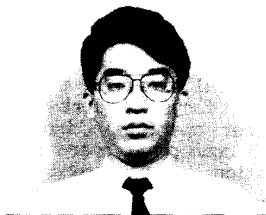
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