34.1: A 33-in.-Diagonal HDTV Display Using Gas Discharge Pulse Memory Technology

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ABSTRACT

Hi-Vision (HDTV; High-definition TV) pictures have been reproduced experimentally on the 33-in. panel with 1024 x 800 cells of 0.65-mm pitch as a first step toward making a Hi-Vision flat panel display. About 40 % of the area of an original Hi-Vision picture of 1125 lines/ 60 fields standard was displayed because of limitations on the numbers of panel cells using a pulse memory drive scheme. Bright color TV pictures were obtained by a stable memory operation in the effective area of the panel.

INTRODUCTION

Flat panel displays, lighter and thinner than CRTs, are desirable if HDTV receivers are to be brought into general use in the home. A display of at least 1-meter in size is required to produce a strong subjective sensation of reality. Table 1 shows an example of flat HDTV display specifications based on the CCIR documents[1]. The value for pixel pitch and subsequent items in the table are estimated to be the minimum required levels. From the viewpoint of the produceability of large-size panels, the gas-discharge panel is considered most suitable, although a memory function has to be introduced into the panel to obtain high luminance.

Fig.1 shows the progress of our color plasma displays in terms of the screen size and number of display cells. Our study on the dc memory panels began with the 3-in. experimental panel[2] as shown in the figure. An 8-in. pulse discharge panel, driven by an improved pulse memory drive scheme based on Holz's[3], showed promising results for application to HDTV displays in terms of luminance, memory margin, and operating speed[4]. Subsequently, 5-in. and 20-in. planar pulse memory panels (PPM panels)[5][6] with simple modified structures were developed which showed uniform characteristics and stable color TV displays. The specifications and performance of the 20-in. panel are shown in Table 2.

Table 1 Example of flat HDTV display specifications

Screen Size	0.8m² min. (0.7m×1.2m, 55-in. dia.)
Viewing Distance	3H(H : Screen Height)
Horizontal Viewing Angle	30°
Luminance	150 cd/m² min.
Contrast Ratio	50 : 1
Pixel Pitch	0.65 mm max
Power Consumption	200 W max.
Luminous Efficacy	1.0 lm/W min.
Thickness	100 mm max.

These planar pulse memory panels, as shown in Fig.2, consist only of two glass plates and do not need any other parts that would complicate panel fabrication. Further, the thick-film printing used

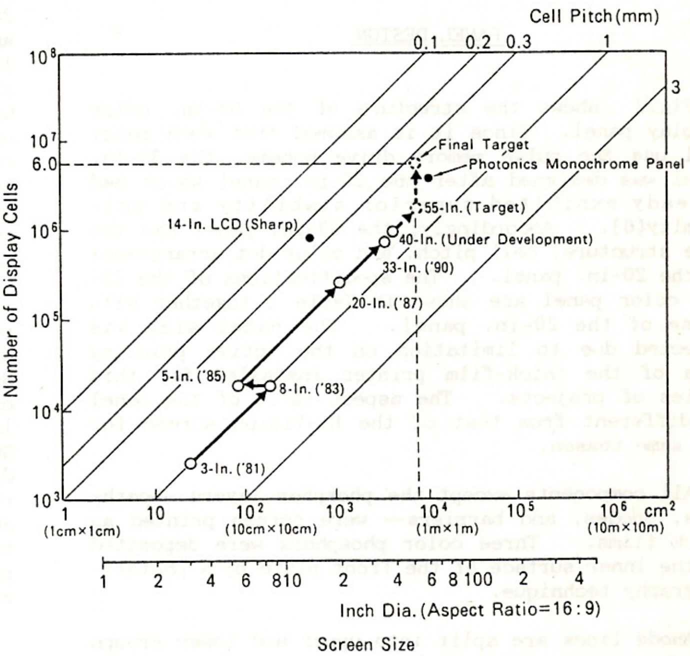
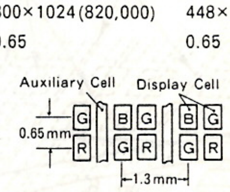


Fig.1 Progress of color TV display using pulse memory panel

Table 2 Specifications and performance of the 20-in. and 33-in. displays

		33-In. Panel	20-In. Panel
Screen Size	(mm²)	520×665	291×416
Number of Display Cells		800×1024 (820,000)	448×640 (290,000)
Average Display Cell Pitch (mm)		0.65	0.65
Cell Arrangement			
Panel Thickness	(mm)	6	6
Panel Weight	(kg)	6	2.4
Phosphor [8]	R	$(Y,Gd)BO_3:Eu^{3+}$	
	G	$Zn_2SiO_4:Mn$	
	B	$BaMgAl_{14}O_{23}:Eu^{2+}$	
Peak White Luminance (cd/m²)		68 (20fL)	55 (17fL)
Luminous Efficacy (White, lm/W)		0.16	0.13
Contrast Ratio		190:1	90:1
Number of Gray Levels		256	256

in panel fabrication is a technique already in current use. It follows that the fabrication of a PPM panel with a large screen size and small cell pitch will be comparatively easy. The introduction of the memory function with the pulse memory drive scheme does not cause any decrease in panel luminance even when the panel size is enlarged.

A 33-in. diagonal color panel with the same structure as that of the 20-in. PPM panel was fabricated to confirm the feasibility of the 1-meter-size panel[7]. Recently, Hi-Vision pictures of 1125 lines/ 60 fields standard have been reproduced experimentally on this 33-in. panel. This paper describes the Hi-Vision display with the 33-in. panel, outlining the features, display system, and performance.

PANEL DESIGN

Fig.2 shows the structure of the 33-in. color display panel. Since it is assumed that such panel will use the pulse memory drive scheme, the 33-in. panel was designed after the 20-in. panel which had already exhibited superior stability and uniformity[6]. Accordingly, the 33-in. panel has the same structure, cell pitch, and color dot arrangement as the 20-in. panel. The specifications of the 33-in. color panel are shown in Table 2 together with those of the 20-in. panel. The panel size was selected due to limitation on the active printing area of the thick-film printer installed for this series of projects. The aspect ratio of the panel is different from that of the Hi-Vision screen for the same reason.

All components except the phosphor layers --cathodes, anodes, and barriers-- were screen printed as thick films. Three color phosphors were deposited on the inner surface of the front plate by a photolithography technique.

Anode lines are split into upper and lower groups almost at the center of the panel, as shown in the Fig.2. The reason is as follows: reproduction of 256-gray-level TV pictures on a panel with 1,000 horizontal lines requires a very fast access time of 2 us for write/erase scanning in the pulse memory drive scheme. A previous study had proved that the developed panel could respond to such a fast access time[4]. In practice, however, a longer access time of 4 us was adopted to ensure stable memory operation. In the case of a panel with more than 500 horizontal lines, like the 33-in. panel, this means that the anode lines of the panel had to be split into two groups. This is the first time a two-lines-at-a-time access scheme has been adopted for the memory panel, excluding its introduction into a line-sequential-address panel[9].

PULSE MEMORY OPERATION

The basic sequences of the pulse memory drive scheme for the 33-in. panel with 800 cathodes are shown in Fig.3. The cathodes numbered from 1 to 384 form the upper cell array with the upper spilt anodes, and those numbered from 385 to 800 form the lower array with the lower split anodes. The two glow-discharge lines in the auxiliary cells of the upper and lower arrays are shifted downward from the upper cells to the lower by the scan pulse on the cathodes. A write access operation assisted by the auxiliary discharge likewise shifts downward on the two arrays. The display cells, once accessed, continue discharging repetitively under excitation by the sustain pulses until the erase pulse is applied.

The 33-in. panel was driven by a two-step sustain pulse as shown in Fig.3. The reason is as follows: electrical capacitance, inductance, and resistance due to the panel electrodes, which generally increase with the panel size, cause electrical oscillation at the rising edge of the sustain pulse. Such oscillation makes peak voltage applied to the display cell depend on its location on the screen, resulting in a lack of both uniformity of luminance and memory margin. Since the slower the rise of the pulse, the weaker the oscillation, the sustain pulse was converted into two steps for a fairly slow-rising pulse shape.

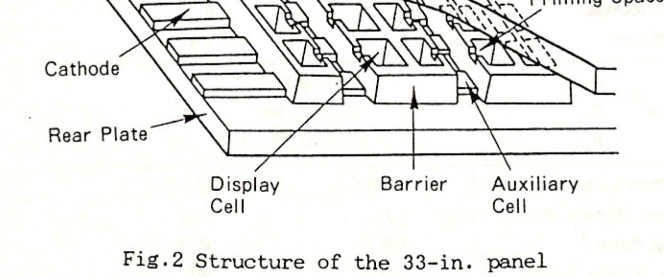


Fig.2 Structure of the 33-in. panel

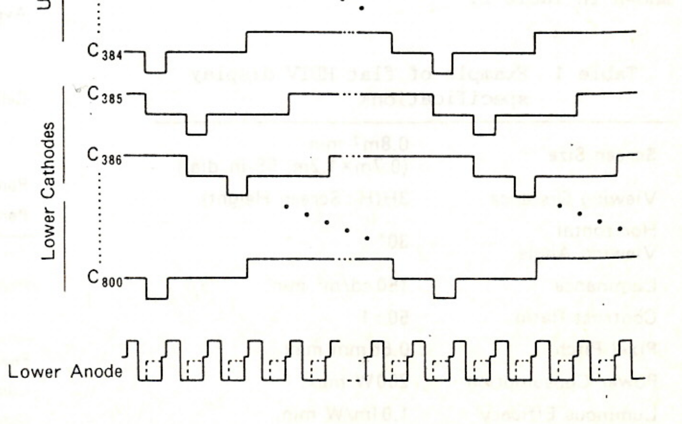


Fig.3 Time sequences for pulse memory drive scheme

Fig.4 shows the relationship between the sustain pulse voltage margin Vm and first step voltage Vfs of the sustain pulse. The sustain pulse voltage margin Vm is given by

$$Vm = (Vsp)max - (Vsp)min, \qquad (1)$$

where (Vsp)max and (Vsp)min are, respectively, the maximum and minimum sustain pulse voltages for stable memory operation. A negative value of the margin Vm shows that stable memory operation is not obtained across the whole panel area. Although the memory margin was very small without the first step, a sufficient margin of 11 V was obtained at a Vm of almost half of a sustain pulse.

HI-VISION DISPLAY SYSTEM

Fig.5 shows a block diagram of a Hi-Vision display system for the 33-in. panel consisting of two main blocks: a signal processor and a 33-in. display. One of the principal functions of the processor is to generate an interpolation signal to enable the progressive scanning of the panel access. The other is to convert the signal format using frame memories so as to fit the pulse memory drive.

The processor was designed to be applicable to a full screen display of Hi-Vision pictures, assuming the current color cell arrangement. Accordingly, input signals of the 1125/60 standard are sampled with a sampling rate of fs=74.25MSPS and with 8 bits/sample. For each primary color, the circuit accepts 1920 effective samples per line and handles 1035 effective lines per field, taking account of the internally appended interpolation signal. In the current application, however, 800 signal lines per field are simply assigned to the 800 panel lines, the rest being abandoned. As a result, approximately 40% of the original Hi-Vision screen area is displayed on the panel, as shown in Fig.6.

Sampled data are first rated down to fs/2, then fed to a progressive scanning signal generator. The progressive scanning signal generator generates a motion adoptive interpolation signal to obtain an odd/even field signal respectively in the even/odd field time, in parallel with the input signal. The input signal plus the generated interpolation signal will be referred to as the progressive scanning signal, although they are not serialized.

After a gamma-correction of gamma = 2.2 to correct the input signal, assuming CRT's gamma, the digital progressive scanning signal is stored in a frame memory. The gray scale is reproduced by superimposing 8 bit-sliced-planes on a television field, which is divided into eight subfields of 2-ms length.

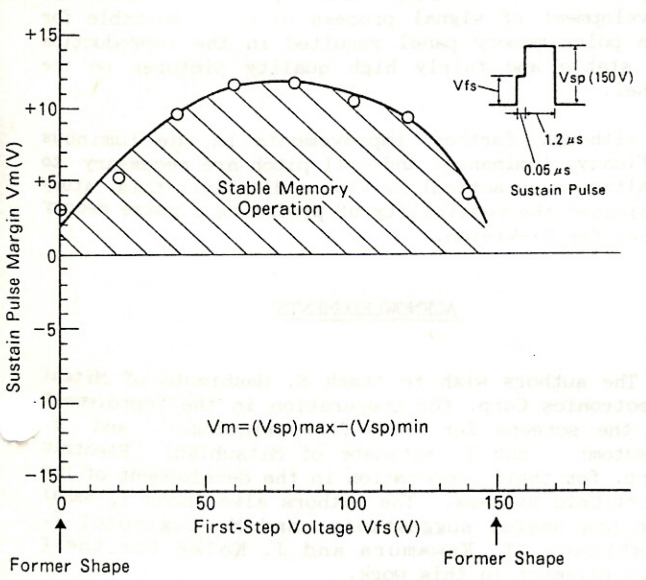


Fig.4 Sustain voltage margin for the two-step pulse

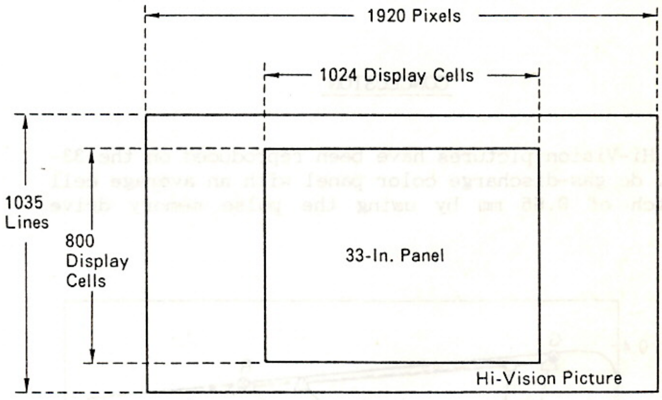


Fig.6 Display area on the 33-in. panel

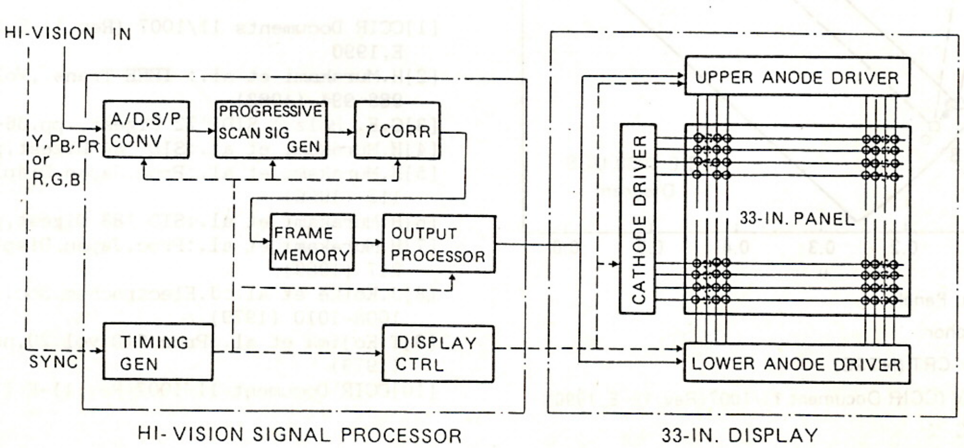


Fig.5 Hi-Vision display system for the 33-in. panel

The bit planes are read out of the frame memory for every subfield and fed into both the upper and lower anode drivers. Finally, 2048 parallel high-voltage write pulses, which are serial-parallel converted in driver boards, are applied to the display anodes together with the sustain pulse common to all display anodes.

The 33-in. display block has upper and lower drivers and a cathode driver. Although the adoption of the two-lines-at-a-time access scheme made the anode drivers fairly complex, the depth of the 33-in. display block could be made less than 15cm by arranging all parts on the boards as compactly as possible.

DISPLAY PERFORMANCE

Table 2 shows the performance of the 33-in. Hi-Vision display, together with that of the 20-in. panel display for comparison. The luminance and luminous efficacy of the 33-in. display were better than those of the 20-in. panel because of the increase in the Xe content of the He-Xe gas-composition in the panel. Fig.7 shows the chromaticities of the primary colors. As can be seen from the figure, the color gamut reproduced on the 33-in. panel is smaller than that for phosphor[8] because of phosphor excitation from the adjacent auxiliary cells through the priming path. Although the color gamut is similar to that of a color CRT, the purity of the primary colors, especially red and blue, is insufficient for the new HDTV standard[10]. Fig.8 shows a photograph of the 33-in. experimental Hi-Vision display.

CONCLUSION

Hi-Vision pictures have been reproduced on the 33-in. dc gas-discharge color panel with an average cell pitch of 0.65 mm by using the pulse memory drive scheme. Stable memory operation was obtained for the two-lines-at-a-time access drive with the introduction of the two-step sustain pulse. Moreover, development of signal process circuits suitable for the pulse memory panel resulted in the reproduction of stable and fairly high quality pictures on the panel.

Although further improvements in the luminous efficacy, luminance, and cell pitch are necessary to realize a practical Hi-Vision display, this study indicated the possibility of producing a pulse memory panel for Hi-Vision.

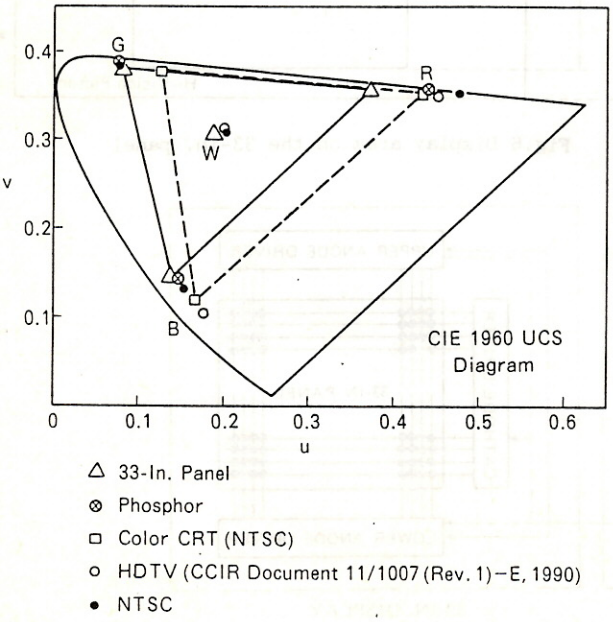


Fig.7 CIE chromaticity diagram

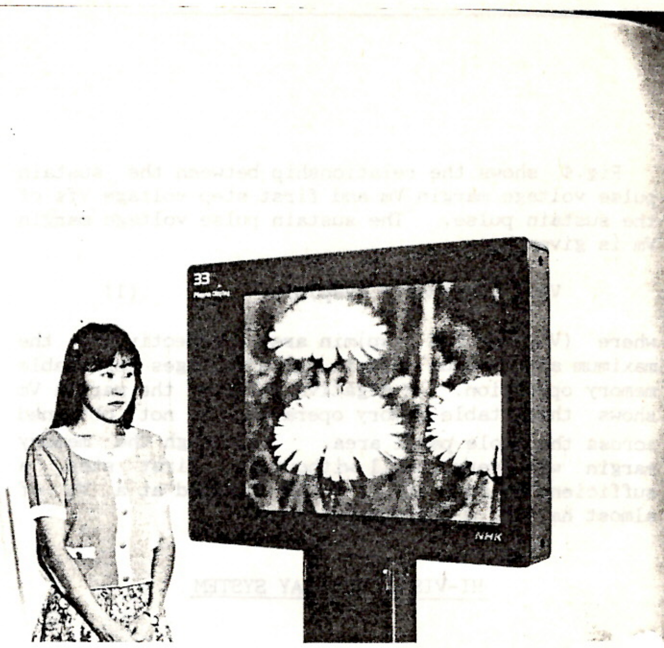


Fig.8 Photograph of the 33-in. display

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