A Study on the Color Performance of FFS Mode Using the Various Analysis Methods

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Abstract

This study focuses on the color characteristics of FFS (Fringe Field Switching). We use various methods to prove the high performance of color characteristics in the Fringe Field Switching mode. We have described a color performance of 15" XGA product by the viewing angle range using x, y parameters of CIE chromaticity diagram. And so we used the 2 dimensional analyzing to prove the color shift distribution by viewing angle.

1. Introduction

From the fifteen years ago, LCD technologies have been studied on the display and all application markets such as mobile phone, PDA, notebook and TV. But LCD has original problems such as narrow viewing angle, response time and color variation because of liquid crystal molecules have optical anisotropy, and so several wide viewing angle technologies had developed by companies and researchers for a ten years [1,2]. Among the proposed technologies that have become reality in recent, only FFS and IPS is original only liquid crystal mode, without additional optical compensation films. The FFS was introduced to be utilize the homogeneous rotation with aligned LC molecules almost co-plane above whole electrode surface, giving rise to high transmittance area unlike in the IPS device [3].

Recently, we have developed AFFS (advanced fringe field switching) technology with an unlimited viewing angle and good color characteristics that obtained from a upgrade of the design rule only by optimization of LC electrodynamics for the first time in the world [4,5].

We will discuss the methods of color analysis about the color shift by viewing angle. The viewing angle data is that resulting projection of XYZ values is the 1931 CIE chromaticity diagram. Goal is to measure changes in color as a distance. This was transformed from base for all color management systems. But the problem with the 1931 chromaticity diagram is that is not constant across the plane of the diagram. Further transformations focus on creating a more uniform chromaticity scale diagram [6-8].

Although many color analysis methods have been created a more uniform chromaticity scale diagram, such as La*b*, Lu*v*, RGB and HSI, it is still difficult to deal with color shift by the viewing angle of LCD. Therefore, we use a various color coordinate for color characteristics analysis by color shift [9-11].

This analysis is change into each color data (Red, Green, Blue, White) by x, y of CIE chromaticity diagram to be include in the full gray. The color representation ability could be analyzed on the three dimensional coordinates such as variations of gray scale, color shift, color gamut, transmittance by view angle. In this paper, we discuss the high performance of FFS color characteristics according to wide viewing angle. And also, we will discuss the reason why FFS have a good display quality for the all color analysis.

2. Study on the Color Analysis in FFS mode

We have used the 15" XGA (1024 × 768) product to study on the color performance. It is possible to obtain viewing angle from -89 to +89 and the contrast ratio rose to more than 450:1 also the color gamut rose to more than 60%. Table 1 shows the summary of the product used to verify the color performance.

15" XGA	Gamut.	Brightness
2 domain	60%	250nits
1 domain	Same	280nits

Table 1. Summary of display quality in 15" XGA

In generally, the CIE chromaticity Diagram xyY shows a special projection of the three dimensional CIE color space XYZ. This is most general method to confirm a color shift according to the view angle.

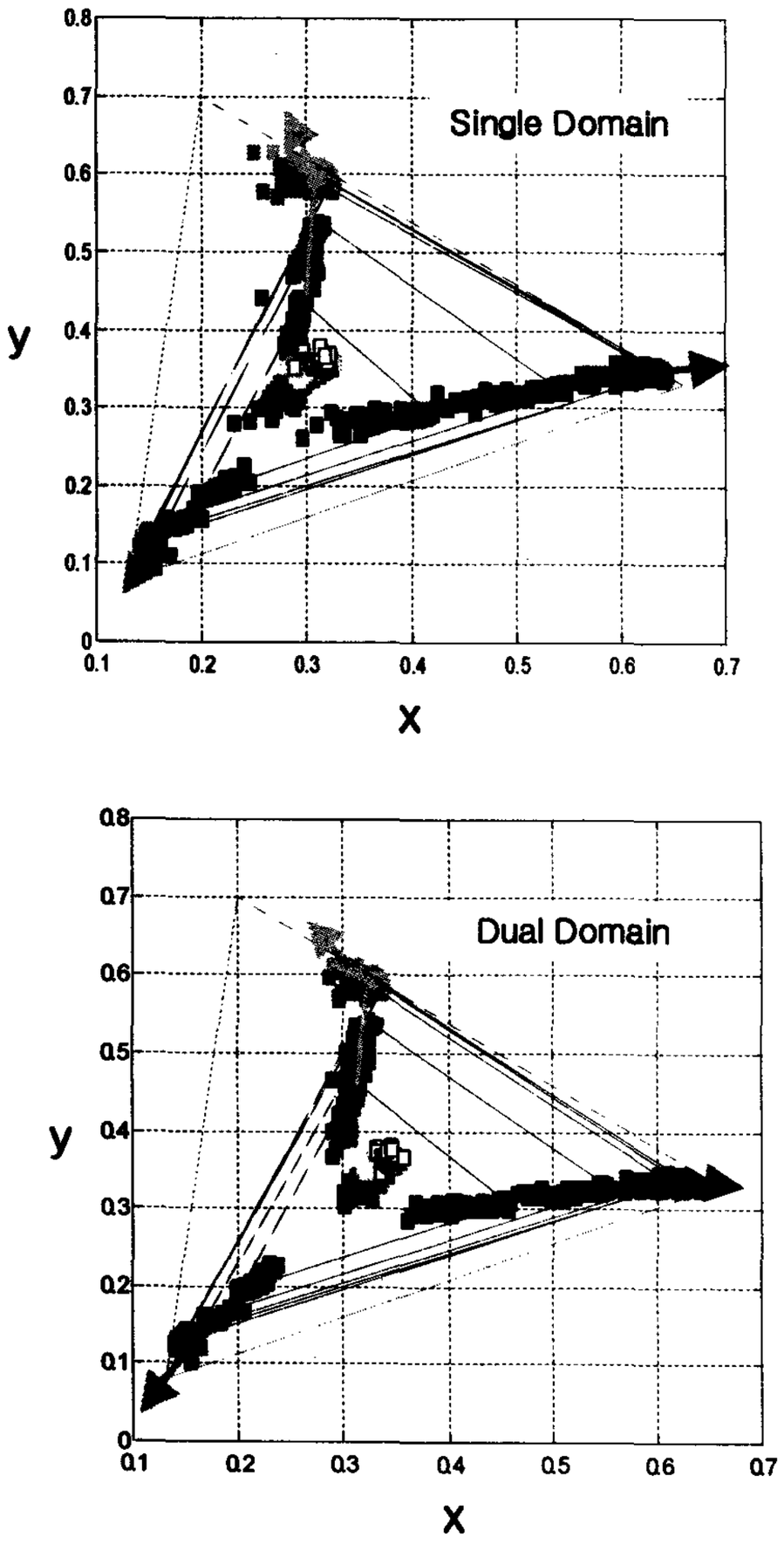

Figure 1. A color shift at full gray in FFS mode with dual and single domain

The Figure 1 shows the color shift patterns of FFS modes about each gray level when the viewing angle is changed from -80° to + 80°. The blue line is connected x, y coordinates data of center view angle about the equal gray level of red, green, blue. The red line is connected gamut for NTSC primaries. From middle gray level to High gray level (L127~L255) indicates that FFS suppresses color (R, G, B, White) shift under 0.02 in the case of dual domain. However, white shift of the single domain in all gray is larger than the dual due to poor compensation of the polarized light to different axis. In spite of the poor compensation, FFS have a lower color shift than the others with over 0.07 [6].

We calculated an absolute distance ($\sqrt{\Delta x^2 + \Delta y^2}$) from a color shift about each gray (Figure 2). A color shift can know in a remainder gray level except the low gray level that we are considerably small. Especially FFS appear very a color shift characteristic of the white so that FFS are superior.

Such a color shift analysis became the localization at the 2-D until now. Accordingly, we implemented the 3-D to represent overall color shift of x, y direction by view angle (Figure 3, 4). The graph shows the advantage which the analysis can do a color shift according to view angle, x, y at the same time. But it is well defined such that all visible color can be defined using only positive values, and, the Y value is luminance. Consequently, a color of the XYZ primary themselves are not visible. The chromaticity diagram is highly non-linear, in that a vector of unit magnitude representing the difference between two chromatic is not uniformly visible in under middle gray level especially.

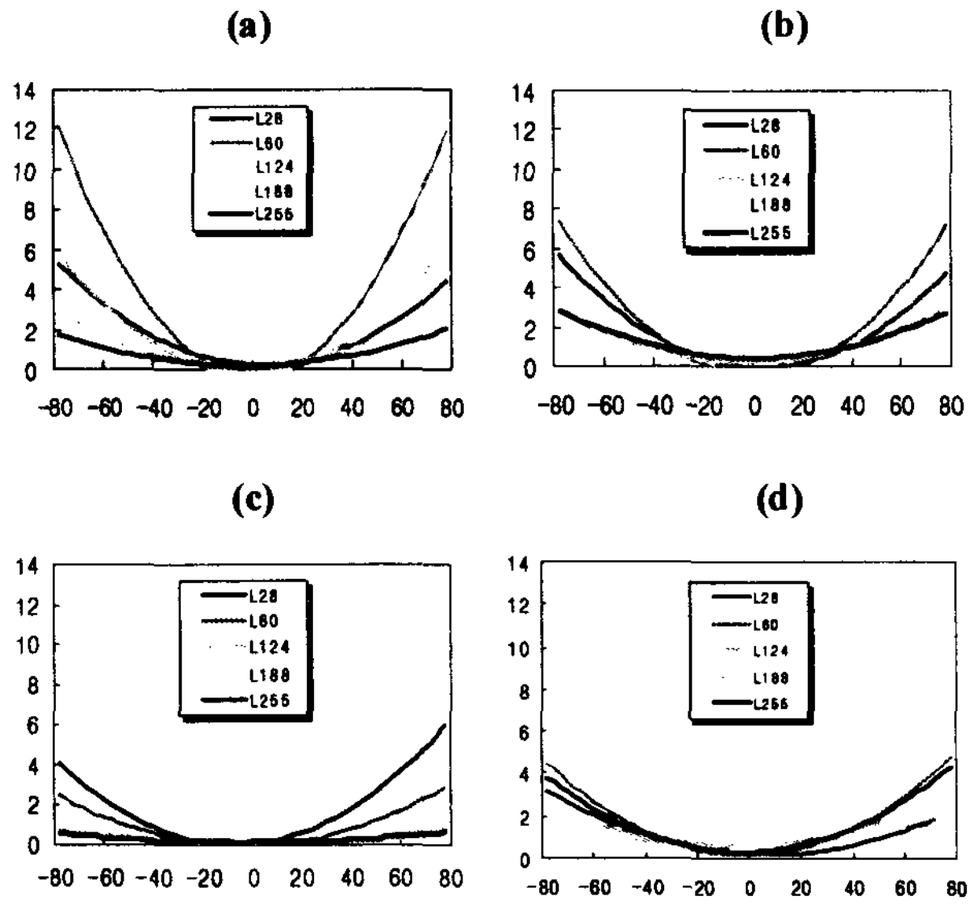

Figure 2 An absolute distance from a color shift (a) red, (b) green, (c) blue, (d) white

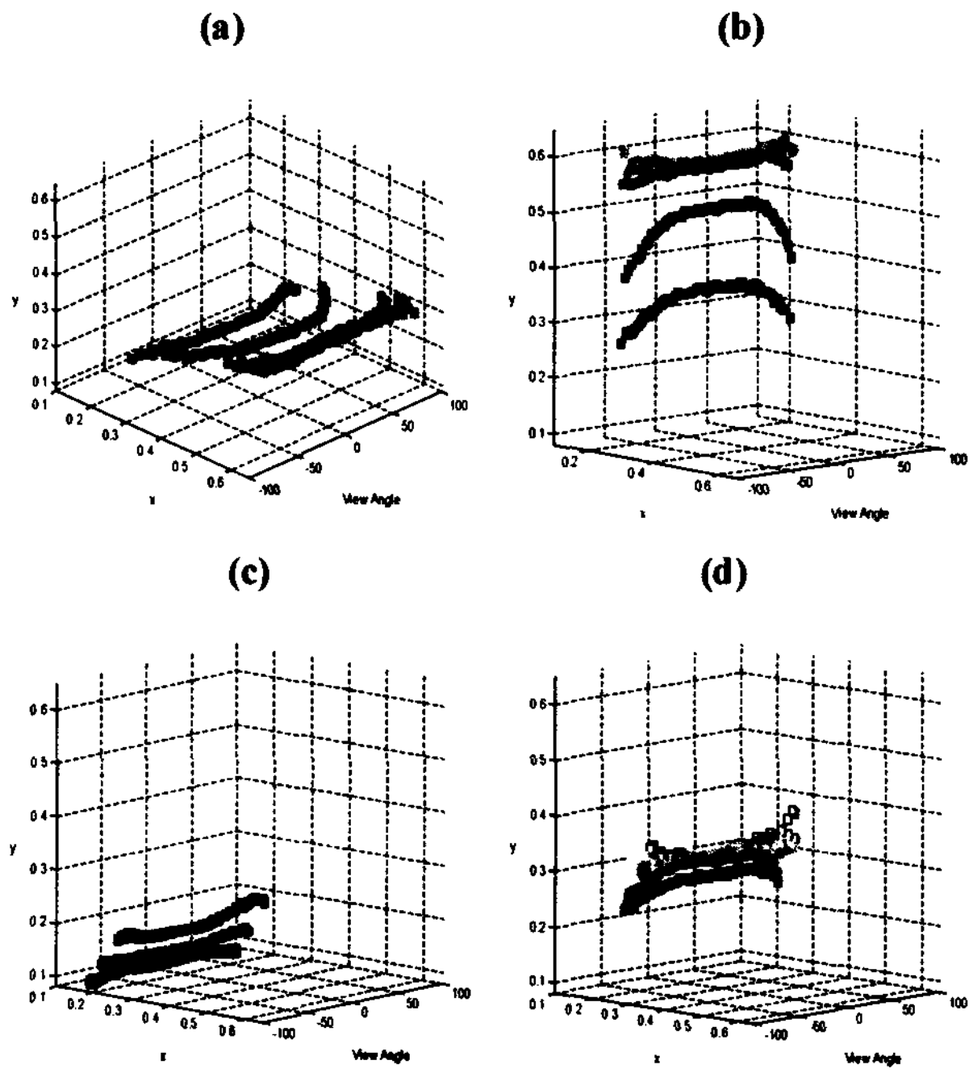

Figure 3 A color shift by view angle (3-D) (a) red, (b) green, (c) blue, (d) white

Figure 4 A color shift by view angle (3-D mesh) (a) red, (b) green, (c) blue, (d) white

So, we have used that hue and saturation is intimately related to the way the human visual system perception for color. Each color can be specified in terms of its Hue (H), Saturation (S) and intensity (I) [9-11]. In short, the HSI model is suited for image color description. Their advantage lies in the extremely intuitive manner of specifying color. The FFS is appearing due to the color shift so that the hue of low gray level is superior as shown as in Figure 5. We know that the analysis method for the deep color representation like as human perceiving can be utilized the three dimensional color method using dual domain FFS. As shown as in all data, color performance of FFS is similar with CRT [11].

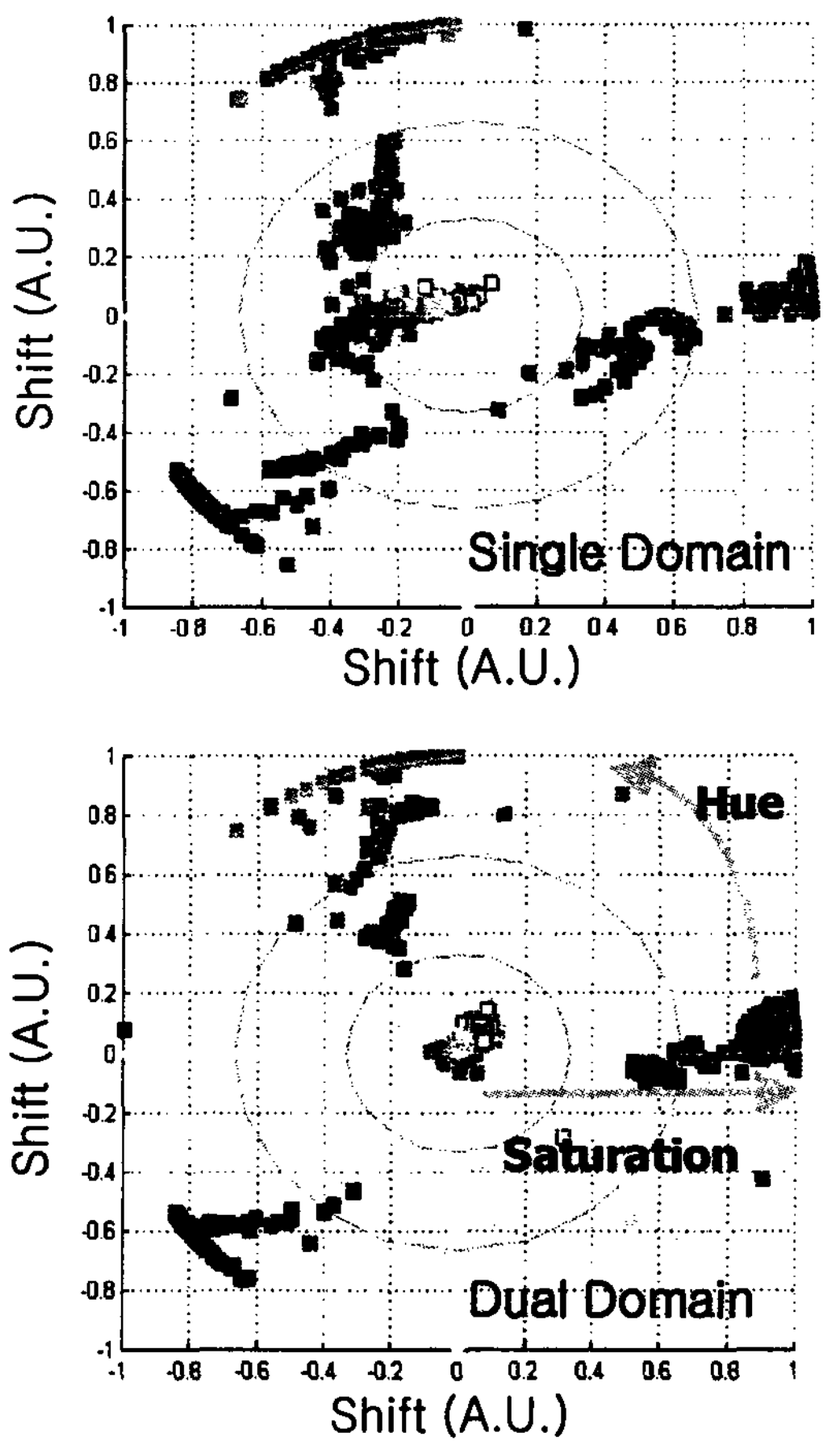

Figure 5 A color shift characteristics of FFS using HSI model for the single and dual domain.

Figure 6 shows the color gamut for the various viewing angle and each gray level. We can know that the representation power is very high and uniform for

all angles. Figure 7 shows the change of intensity of color shift in white axis using HIS model. We can be verified the high intensity with good.

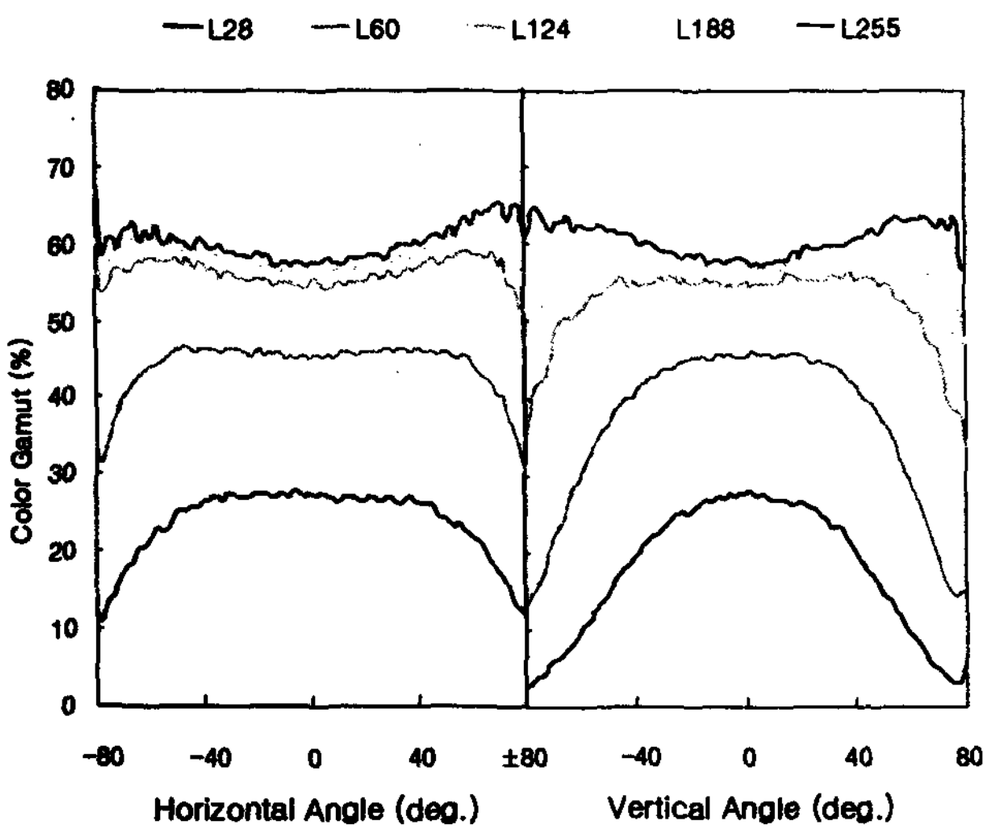

Figure 6. Color gamuts versus view angle and gray.

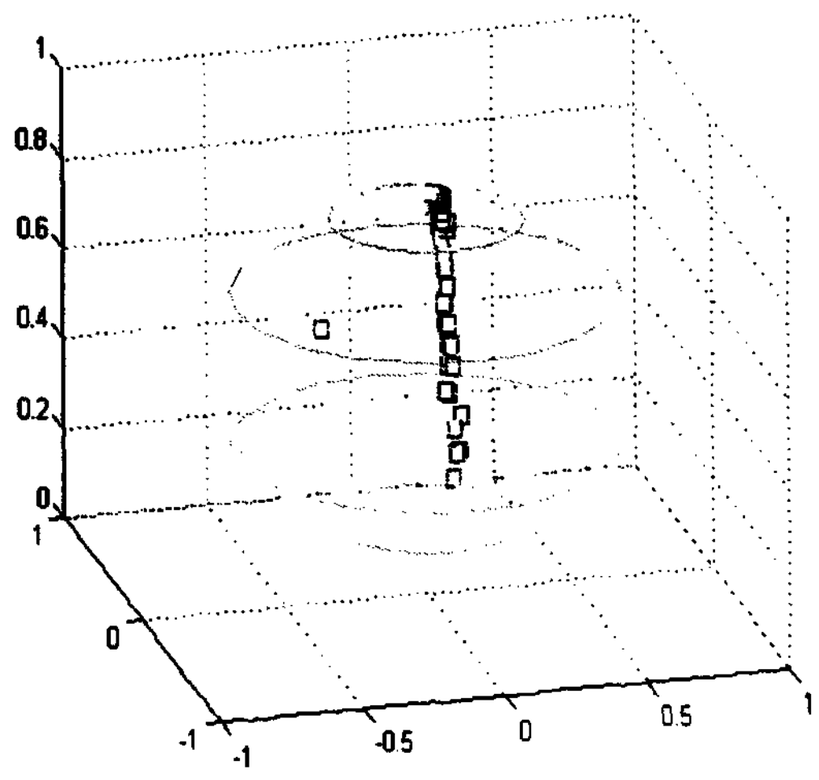

Figure 7. White color shift characteristics of FFS using HSI model in L255.

3. Results and discussion

Color performance of the FFS was realized by revised analysis method by using three dimensional coordinate. The blue line of Figure 1 can know near at NTSC as changed gray level. The color reproducibility and gamut of FFS with all angles and gray levels shows the super high performance as like as CRT. And also, when we compare with color shift and absolute amount, as shown as Figure 3, a color shift can be minimized according to the view angle obviously. FFS can know here that the color shift characteristics are considerably good. The utility of HSI model appear the hue variation about a color shift of FFS.

4. Conclusion

We use various methods to prove the super high performance for CRT like color characteristics of FFS mode using x, y parameters of CIE chromaticity diagram. All data was summarized by a color shift distribution by viewing angle and gray level through the three dimensional analysis. Accordingly, we have proved that FFS can be obtained a nearly free in the three dimensional color shift of x, y direction by full viewing angle and gray level. As results, we could be convinced that FFS is the best solution for the personal TV, HDTV and multimedia like CRT.

5. References

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