Invited Paper, A novel LCD using S-IPS technology for the application of public display

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Abstract

A novel configured S-IPS LCD has been developed introducing a new compensation film with an anti-reflective layer. This new technology provides wide viewing characteristics as well as excellent visibility under bright indoor lighting or natural lighting.

1. Introduction

S-IPS technology has already been adapted in larger size LCD TVs as well as monitor by the merits of LCD performance such as wide view angle, fast motion picture and low power consumption etc.[1,2] In addition, S-IPS technology has been applied in the Public Information Display(PID) application such as shopping malls, indoor and outdoor advertisements, public transport ; bus and airport terminal etc.

The potential of PID market is unlimited because all the signs/displays we see everywhere can be transformed into digital devices. For the wide usage of the PID, it requires some endeavors; black level in whole viewing directions, sunlight visibility, and reliability based on the current LCD TVs.

Outdoor display applications, especially, under direct sunlight illumination or bright indoor, require very bright LCD. Recently, sunlight-visible LCDs with its screen brightness exceeding 1,000cd/m^2 have become commercially available. However, it is not sufficient for good visibility under very bright ambient illumination. The higher the brightness of the backlight becomes in order to surpass the surface reflection of the panel, the more the power consumption increases.

Usually, the surface glare caused by the ambient illumination can deteriorate the contrast ratio (CR) of the LCD so that the image may not be read easily. Reflectivity of the panel is critical for high ambient light conditions.

In this paper, we review how to reduce reflection of the panel and to introduce the new S-IPS technology which is combined with new retardation film to improve the outdoor visibility and viewing angle characteristics, simultaneously.

2. Panel structure and visibility measurement

Fig.1 shows the optical configuration of the S-IPS LCD with a different type of polarizer. As a conventional S-IPS, Fig. 1(a) is combined with normal polarizer and anti-glare (AG) coatings, and Fig. 1(b) is combined with normal polarizer and anti-reflective (AR) coatings. As a novel S-IPS, Fig. 1(c) is combined with retardation film and AR coatings. IR is the incident ray, Rp is the reflected ray at the polarizer surface, Rin is the reflected ray at the glass and the reflection from inner panel.

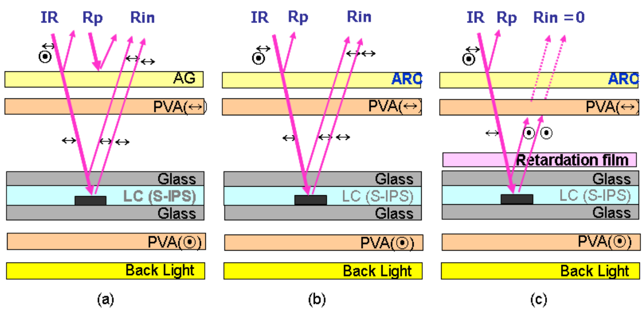

Fig. 1. Optical configurations of three difference types S-IPS LCD. (a) AG + Normal POL, (b) ARC + Normal POL and (c) ARC + Retardation film

When a beam of ambient light is incident to an LCD, the first reflecting surface encountered is the front surface of the top polarizer. Subsequently, light reflections may occur at the surfaces of the front glass, the light shielding layer, the electrodes and the metal bus-line of TFT and so on. Among all these layers, the front surface of the top polarizer usually contributes the majority of the reflected light. To obtain the extremely low reflection of the panel, it needs to be considered on how to reduce the Rin. As a Fig.1 (c), circular polarizer eliminates reflections by proper retardation film. Rin is absorbed at the polarizer after it passes through the retardation film.

We prepare three types of 42-inch S-IPS LCDs; AG or ARC with normal polarizer, ARC with retardation to measure the legibility of LCD under various ambient light conditions. The measurement system consists of the fluorescent lamps with diffuse plate for similar conditions with real external environment. The panel was positioned 45° to the horizon in this system. A photometer (PR 880) was set 100cm apart from the LCD.

3. Results and discussion

The CR of LCD is defined as the ratio of the luminance of white state and black state in dark room. For a given LCD, its CR is greatly affected by the ambient light.[3] If the light reflected by the surface of display is close to or greater than the amount of light emitted by the display, it can not be seen.

Fig.2 shows the CR under the various ambient light conditions; indoor and semi-outdoor. The CR decrease for all of the cases as the ambient light increases. This is because the surface reflection makes the dark level higher. The AG with normal polarizer has worst CR value among the three samples. AG-coated surface which is combination of diffuse, spreading and specular surfaces causes high surface reflection. The AR coatings are very effective in reducing the surface reflection of the panel in bright ambient conditions.

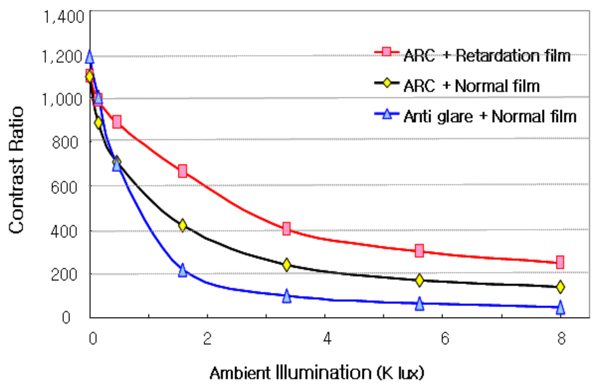

Fig. 2. Contrast ratio as a function of indoor and semi-outdoor illumination intensity.

In particular, new polarizer combined with retardation film and AR-coating has the best CR value. This is because the circular polarized light was eliminated by the compensation structure of S-IPS LCD. As a shown in Fig. 1(c), unpolarized light goes through a linear polarizer and becomes polarized in the same direction as the polarizer's axis. The light then goes through a retardation film as a role of quarter-wave and becomes right-circular polarized. Circularly polarized light changes orientation when it bounds off the surface so the reflected light becomes left-circular polarized. When the light goes back through the retardation film again, it reverts to linear polarization. The linear polarizer therefore blocks the reflected light

Fig.3 shows the black level of each case of S-IPS mode. When the illumination intensity increases the black luminance of the panel remarkably increases. In the case of conventional S-IPS LCD, AG or ARC with normal polarizer, the black luminance are over 12 or 5 cd/m^2 at the 8,000 lux, which corresponds to the overcast condition, respectively. In the case of novel configuration which is combined with retardation and AG-coatings, the black luminance are 3cd/m^2 at the same condition which is good visibility for bright indoor and semi-outdoor PID applications.

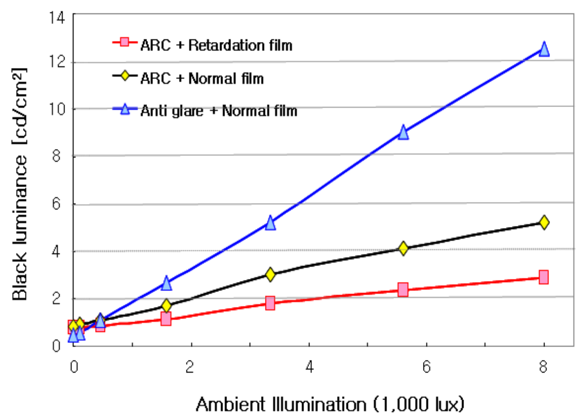

Fig. 3. Black luminance as a function of indoor and semi-outdoor illumination intensity.

Fig. 4 (a) and (b) show the image of conventional and novel S-IPS LCD under the bright illumination intensity, 8,000 lux. As shown in these figures, sufficient visibility is obtained in the novel S-IPS, using retardation film with AR-Coating at bright illumination condition. In this case, CR is over 250:1 compared with 50:1 of conventional polarizer with AG-coatings.

Fig. 4. Comparison of display images on the S-IPS LCD using (a) AG + normal polarizer and (b)ARC+ retardation polarizers under the bright illumination intensity at 8,000 lux.

For the PID application, the image quality needs to be maintained under any outdoor conditions; day and night and viewing directions. Fig. 5 (a) and (b) show the Iso-contrast of conventional and novel S-IPS LCD at dark state, respectively. They show that the retardation film with AR-coatings are improved CR in all azimuthal directions compared with normal polarizer with AG.-coatings.

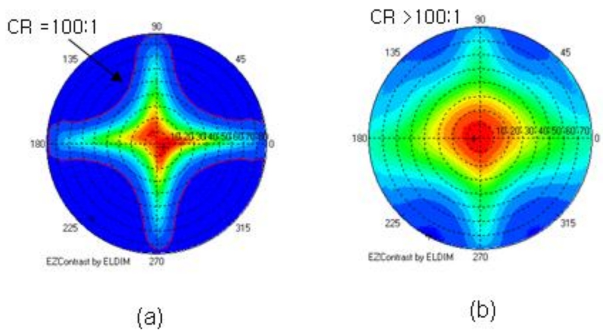

Fig. 5. Iso-contrast contour maps of (a) AG+Normal POL and (b) ARC+Retardation film S-IPS LCD at dark states.

4. Summary

The outdoor CR depends on the surface reflectance of the front polarizer, the reflectance of the inner cell and the brightness of the panel etc. Among three samples tested, normal polarizer with AG-coating or AR-coating do not perform well in outdoor environment.

, The outdoor-visible S-IPS LCDs with novel polarizer which has retardation layer and AR-coating can maintain a high CR (>250:1) at the illumination intensity of 8,000 lux with providing good display image under the bright indoor or outdoor conditions.

5. References

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