Compensation method of antiferroelectric liquid crystal device's characteristics' variation caused by temperature changing

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ABSTRACT

The antiferroelectric liquid crystal (AFLC) display is promising for its tristable switching, no-ghost effect and good mechanical stability. Recently, Yamamoto et al. have realized the full-color AFLC display with analog gradation based on in-pixel domain switching. One of the most advantage of AFLC device compared with FLC device is that it can realized gray level display. But AFLCD characteristics has dependence of temperature. In our experiment, AFLCD was prepared to study this problem. The panel's threshold voltage, cone angle, response time, contrast ratio and electro-optical curves was measured at variable temperature. And we discussed the mechanism of gray level's distortion while the temperature changed in the case of the same driving scheme applied. At last we brought out a proposal to solve this problem. The electro-optic curves of AFLCD in a temperature range was measured. Some temperature sensors were put on the panel to detect it's temperature, and we set a temperature standard. Compared the detected temperature and the standard, and then adjust the electric wave forms to get the same gray levels at variable temperature.

Keyword : antiferroelectric liquid crystal, threshold voltage, cone angle, response time.

1. INTRODUCTION

Surface stabilized ferroelectric liquid crystal (SSFLC)\textsuperscript{12} display has many advantages, such as fast switching speed, wide viewing angle. That made it possible to realize video display. But cause it is difficult to get good alignment, has shock problem, and is difficult to realized gray lever, that limited its variable feature of LCDs. A few years ago, an antiferroelectric smectic phase was discovered in MHPOBC\textsuperscript{34}. Compare with FLCDs, AFLCDs is much easier to get food alignment, realize gray level, and has good anti-shocking property. It has become one of the most hopeful material\textsuperscript{56}. In our experiment, AFLC panel was prepared. And its characteristics, such as electro-optic curve, cone angle, switching time, were measured at different temperature. We discussed the mechanism of AFLC's gray level distortion which caused by temperature variation. At last we brought out a proposal to solve this problem.
2. EXPERIMENTS

AFLC material used in our experiment is Mx-N-14-5. And its phase sequence is as follow:

\[ S_{\text{A}}(0^\circ) \rightarrow S_{\text{SA}}(67^\circ) \rightarrow S_{\text{A}}(102^\circ) \rightarrow S_{\text{0}} \]

2.1 AFLC panel's preparation

In the experiment, the alignment film is PI which can cause low pretilt angle in STN cells. And the cell spacer is 2\( \mu \)m. The rubbing direction on two glass was parallel, because parallel rubbing can cause good alignment. AFLC material was filled into the cell at isotropic phase. Then lower temperature very slowly. Especially at the phase transmission point, the temperature lowering speed is 0.5 °C per hour. After the sample were prepared, we used polarizer microscope to observed the texture of the panel. And it is shown in figure 1.

![AFLC panel's texture photograph](image)

FIGURE 1. AFLC panel's texture photograph

2.2 Measurement of AFLC panel's electro-optic curve

The variable voltage was applied on the panel, and the light transmission was recorded by the computer. The AFLC panel's electro-optic curve is shown in figure 2.
2.3 Measurement of AFLC panel's threshold voltage at variable temperature

We measured the sample's threshold in the meantime after the temperature. The testing result shows in the figure 3. \( V_{90} \) is the threshold when the voltage rise, and \( D_{90} \) is the threshold when the voltage decrease.
2.4 Measurement of AFLC panel’s switching time at variable temperature

Square wave form was applied on the panel, and the light transmission was recorded at variable temperature. And the panel’s switching time was calculated by computer. The result is shown in figure 4.

![Figure 4](image_url)

**FIGURE 4.** AFLC panel’s switching time vs. temperature

2.5 Measurement of AFLC panel’s cone angle at variable temperature

Polarizer microscope was used to measure the cone angle when the temperature changing. The result is shown in figure 5.

![Figure 5](image_url)

3. DISCUSSION

From the figure 3, we can see that if the temperature rise, the threshold voltage will decrease. So if we apply a certain voltage wave form to get a certain light transmission, when the temperature rise, the transmission will increase too. From figure 5, we can see that cone angle of the panel’s variation is too little to be considered when the temperature change. So we consider the mechanism of gray level’s distortion caused by temperature is that electro-optic curve will change when the temperature alter. According to rule of distortion, we brought out a proposal to solve this problem. Some temperature sensors were put on the panel to detect it’s temperature, and we set a temperature standard. Compared the detected temperature and the standard, and then adjust the electric wave forms to get the same gray levels at variable temperature. Furthermore experiment is prepared.
4. CONCLUSION

In this paper, good alignment AFLCD panel was prepared. And its threshold voltage, cone angle, switching time, and electro-optic curves were measured at variable temperature. According to the testing result, we discussed the mechanism of gray level’s distortion caused by temperature. We consider the mechanism of gray level’s distortion caused by temperature is that electro-optic curve will change when the temperature alter. At last, we brought out a proposal to solve this problem. That is to adjust the driving wave form when the temperature alter.

5. REFERENCE
