# The LCOS Optical Engine Evaluation and the Temperature Measurement

Chi-Neng Mo, Ching-Chung Chen, Shih-Min Wu, Chia-Lin Liu,
Central Research Institute, Chunghwa Picture Tubes, Ltd.
1127, Hopin Rd., Padeh City, Taoyuan, Taiwan, 334
E-mail: mocn@cptt.com.tw Tel. +886-3-3675151 Fax. +886-3-3773159

Hun-Wei Chen, Ming Chang
Chung Yuan Christian University

## Abstract

The discusses of this study is that we combined the systems with a new type of LCOS optical engine and the latest color management of LMS to measure the distribution of illuminance, chromaticity and Contrast on the big size of the screen and we will focus on the distribution of temperature at the surface of the PS converter under the heat to evaluate the effectiveness of the heat dissipated faculty of the optical engine system. It will support that we design and fabricate the optics devices and optical engines.

**Keywords:**

*Illuminance, Chromaticity, Contrast, View Angle*

## 1. Introduction

The LCOS technology is based on the semiconductor and LCD industry. As it is manufactured through the standard CMOS semiconductor process, it has the potential strength to be offered at low price with high resolution. Apart from the panel, the whole set of LCOS TV requires the complement of a functional projection display optical system to reveal the strength of LCOS display. The improvement of image quality is the issue that all projection display systems have to face

The source of heat in a projection system is the lamp, the heat could result in the deformity of the supporting structure of optical engine, destroy the coating of optical components, and cause the thermal stress [1]. The inner state of an optical engine is in high temperature due to the emission of strong light. Both the residual stress of the PS converter and the additional thermal stress caused by high temperature can decrease the flatness of the surface of PS converter and change the transmission rate of the material. Therefore, the phenomenon of light leakage during dark state and uneven brightness and color during white state will occur [2]. The impact of heat to a projection system is an important issue. We have an initial solution to prevent the light leakage in the dark state, and we are processing further experiments and analyses

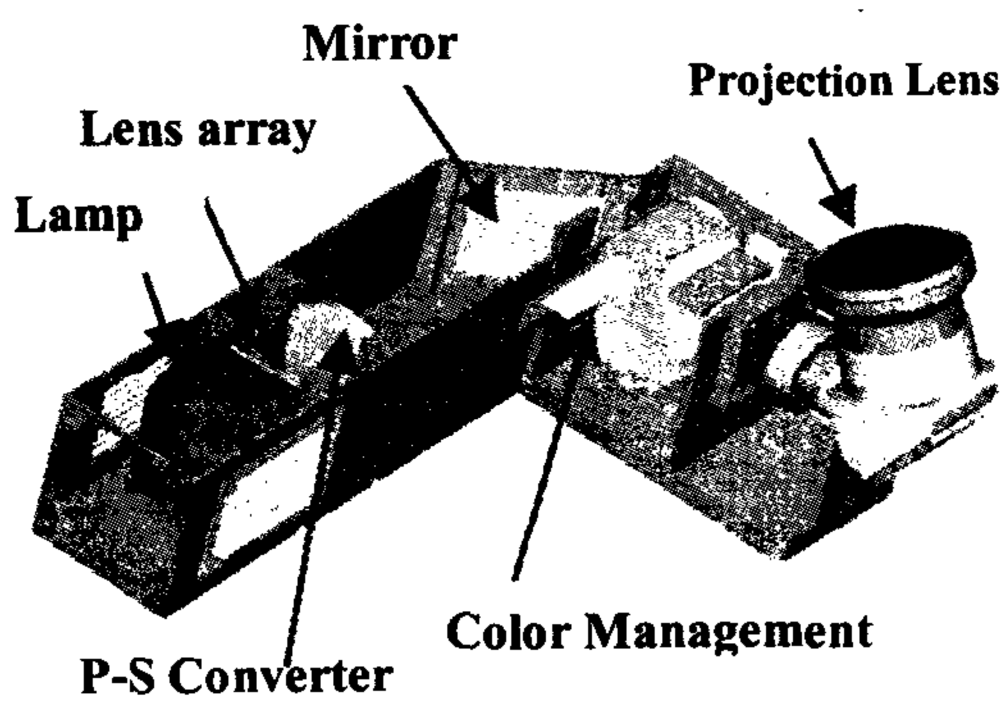


Fig.1 CPT LCOS optical engine model.

The kernel designed by LightMaster System Inc was adopted in this experiment [3][4]. Based on the accumulation of experiences in the development of optical engine technology and the optimized system integration design, we completed a high quality optical engine that is ideal for mass production (as shown in Fig.1). Besides, we create a series of integration plans to elevate the image quality of the projection display system, which are currently under research and development.

## 2. Optical Measurement

### 2.1 Light Output Measurement

According the definition of ANSI, the light output of a projector is measured by taking the value of luminance from the central point in each of the evenly divided 3x3 grid on the projected screen at the state of 100% white image. This value is used to evaluate the luminance and the brightness uniformity. To evaluate the brightness uniformity, we take the maximum and minimum value of luminance from the 13 measuring points (as shown in Fig.2) and calculate their difference from the average value and the values they are divided by it. We can therefore get the zone of the distribution of the brightness uniformity.

Experiment Condition:

a. Room temperature:20℃~23℃
b. Comparative humidity:65%
c. Lamp pre-heating time: 30 minutes
d. Environment: dark without reflective object (environment luminance < 1 lux)
e. People in the lab should wear dark clothes unable to reflect light
f. Testing equipment：CA-210U luminometer

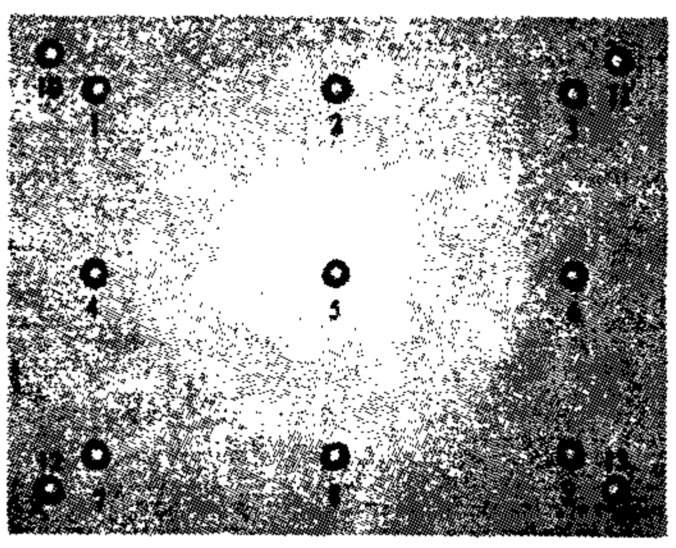

Fig.2 The picture to measure the luminance.

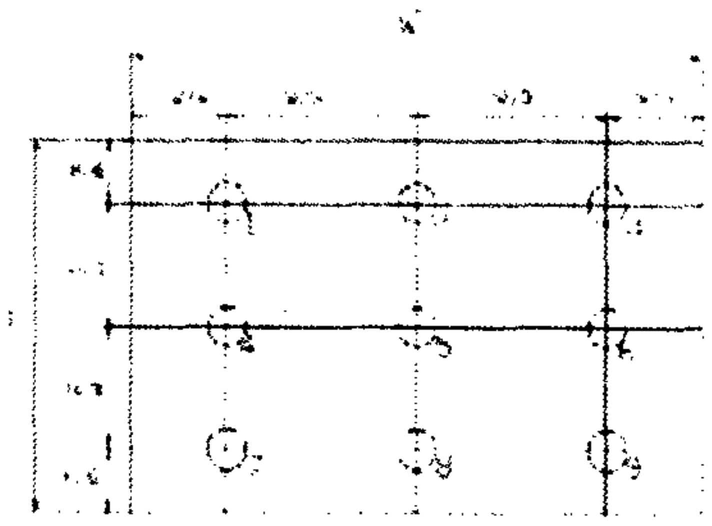

Fig.3. The measured points on the screen.

We take a 1,180mm *680mm TOPPAN screen, peak gain:4.0, in our experiment and measure the luminance of the 13 points on the screen (as indicated in Fig. 2 and Fig. 3). We place the LCOS optical engine on the cabinet to measure the luminance at both white and dark state. As indicated in Table 1 and 2, the maximum value of luminance is 540 nits, the minimum value is 440 nits and the average is 476 nits. The brightness uniformity is -14.54% ~ +13.45%. The average luminance value is 0.58 nits at the dark state and 476 nits at the white state.

Tab.1 The white state luminance.

| | | | | |
|---|---|---|---|---|
| 412.0 | - | - | - | 406.8 |
| - | 452.5 | 484.7 | 440.6 | - |
| - | 470.2 | 540.0 | 473.2 | - |
| - | 467.8 | 506.0 | 452.2 | - |
| 416.2 | - | - | - | 420.1 |

Unit: nits

Tab. 2 The dark state luminance.

| | | | | |
|---|---|---|---|---|
| N.A. | - | - | - | N.A |
| - | 0.59 | 0.63 | 0.52 | - |
| - | 0.63 | 0.66 | 0.52 | - |
| - | 0.56 | 0.64 | 0.48 | - |
| N.A. | - | - | - | N.A. |

Unit: nits

### 2.2 Contrast Ratio

After we measure the values of luminance from the center point at each of the evenly divided 3x3 grid on the projected screen at both white and black image, we can get the contrast ratio by divide the value of luminance at white image with that at black image. The average contrast ratio we get from our calculation is 821: 1.

### 2.3 View Angle Measurement

The luminance of the light output from LCOS TV will vary by viewing angles (as shown in Fig. 4). The luminance will be greatest as we face the screen in the center front (at 0° degree). The luminance will decrease as the degree of viewing angle increases. The purpose of this measurement is to examine the difference of optical efficiency of the projection screen. We take the center of the screen as the bench mark and measure the luminance with the horizontal and vertical angle at 0°、15°、30°、45°、60°、75° (as indicated in Fig.3 and Fig.4). We also estimate the degree of viewing angle when the luminance decreases as 1/2、1/3 and 1/5 of the its highest luminance value. Take the Toppan Screen for example, when the luminance decreases by 1/2, the horizontal viewing angle is at 30° and vertical viewing angle is at 30°. Fig. 5 and Fig. 6 indicate the negatively related relationship between luminance and the horizontal and vertical viewing angles.

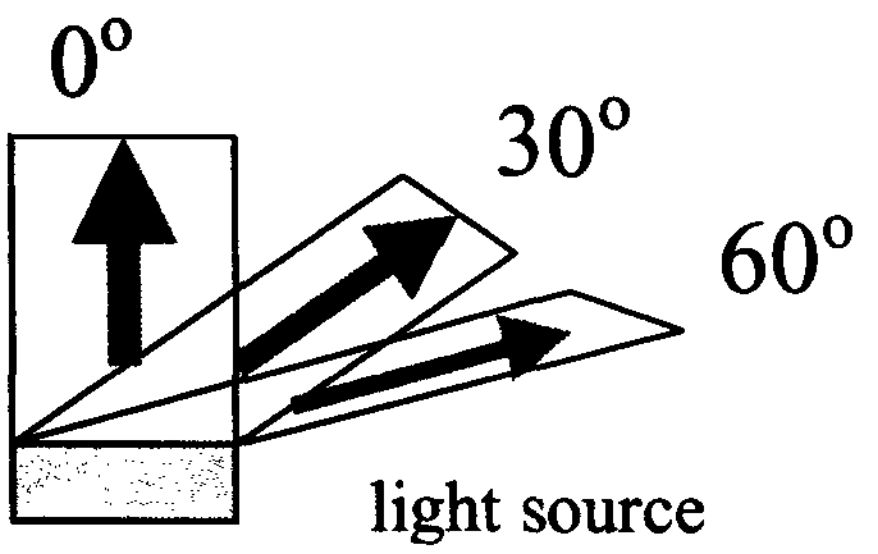


Fig. 4. The luminance decreases as the degree of viewing angle increases.

Tab. 3 The horizontal view angles.

| Viewing angle (H.) | 0° | 15° | 30° | 45° | 60° | 75° |
|---|---|---|---|---|---|---|
| White | 540.0 | 362.7 | 262.4 | 68.6 | 29.7 | 2.2 |
| Viewing angle (H.) | 0° | -15° | -30° | -45° | -60° | -75° |
| White | 540.1 | 369.9 | 280.4 | 72.2 | 36.9 | 2.7 |

Unit: Nits

Tab. 4 The vertical view angles.

| Viewing angle (H.) | 0° | 15° | 30° | 45° | 60° | 75° |
|---|---|---|---|---|---|---|
| White | 541.5 | 417.2 | 184.5 | 80.3 | 50.6 | 2.1 |
| Viewing angle (H.) | 0° | -15° | -30° | -45° | -60° | -75° |
| White | 541.5 | 424.4 | 220.5 | 91.0 | 54.2 | 4.1 |

Unit: Nits

Table 5. The degree of horizontal viewing angle at different luminance (center point concerned)

| | $B_1$ | $B_{1/2}$ | $B_{1/3}$ | $B_{1/5}$ |
|---|---|---|---|---|
| horizontal viewing angle | $0^0$ | $30^0$ | $35^0$ | $40^0$ |

Unit: Degree

Table 6. The degree of vertical viewing angle at different luminance (center point concerned)

| | $B_1$ | $B_{1/2}$ | $B_{1/3}$ | $B_{1/5}$ |
|---|---|---|---|---|
| vertical viewing angle | $0^0$ | $25^0$ | $30^0$ | $35^0$ |

Unit: Degree

(Note : $B_{1/2}$ means the luminance decreases as 1/2 of highest value of luminance)

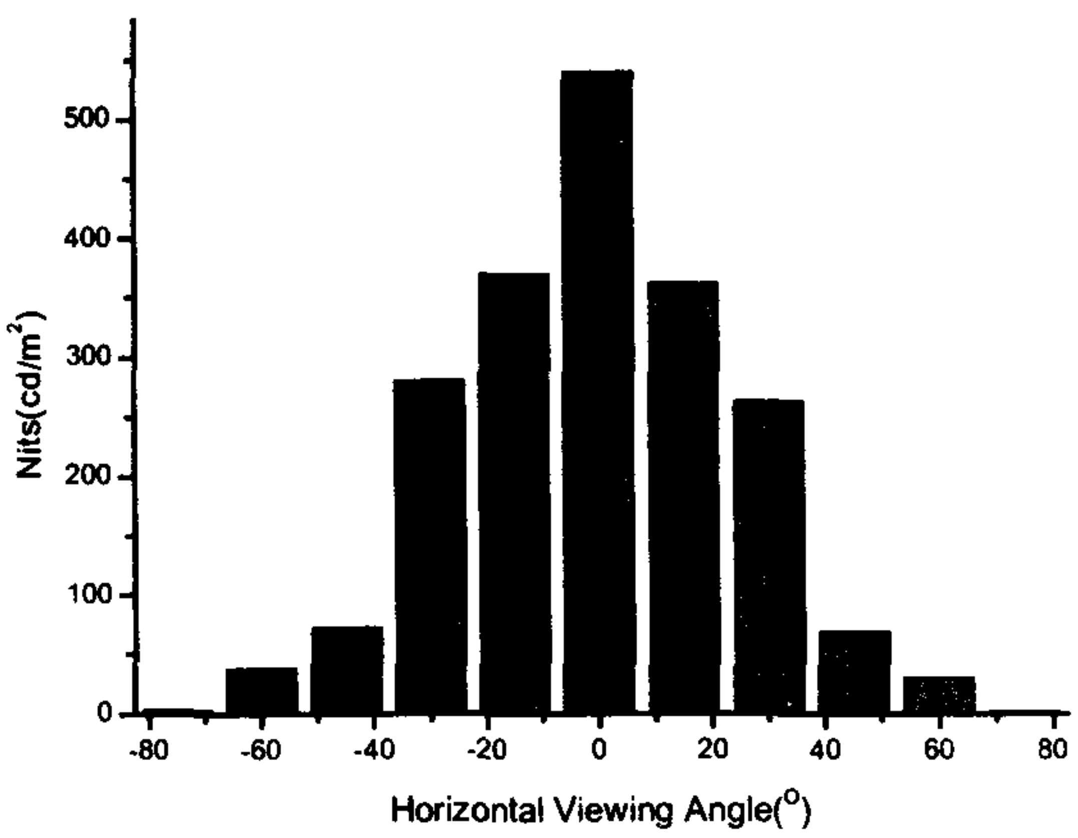


Fig. 5 The luminance at different horizontal view angles.

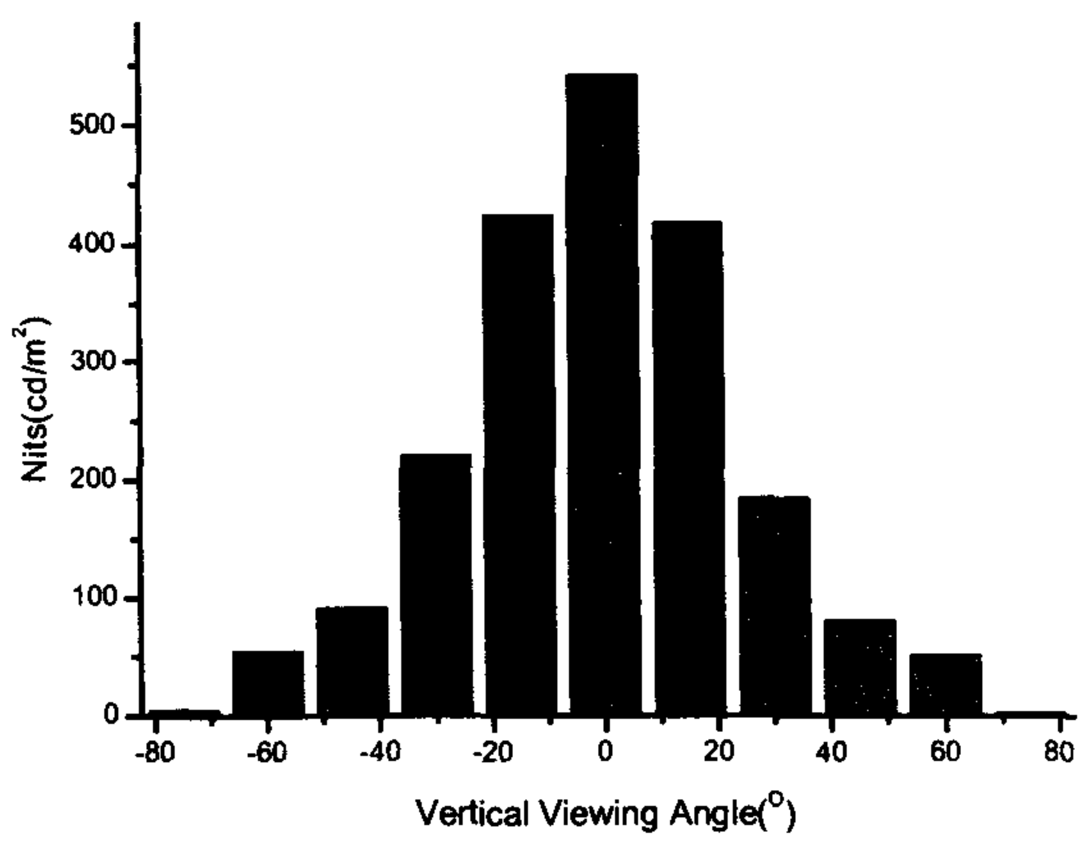


Fig. 6 The luminance at different vertical view angles.

### 2.4 The measurement of the temperature of optical engine

The design of heat dissipated system will directly influence the reliability of the LCOS optical engine. The heat of lamp can result in the deformity of the supporting structure of optical engine, destroy the coating of optical components, and cause the thermal stress and heat effect variation of LCOS panel, etc.. As the PS converter is the closest to the light source and its interface coating will be most seriously impacted by the heat and may result in the deformity, decomposition and decay, we will focus on the distribution of temperature at the surface of the PS converter under the heat to evaluate the effectiveness of the heat dissipated faculty of the optical engine system. We measure the temperature by thermal couple from 6 different points (as shown in Fig. 7) at the surface of PS converter under the light. The results are listed on the Table 7 and the highest temperature is at 77.2°C. Our experiment indicates that the influence of temperature to the optical engine has been effectively reduced due to the design of heat dissipated system.

Tab. 7 The temperature measurement on the PS Converter.

| Situation | Temperature (℃) |
|---|---|
| 1 | 39.2 |
| 2 | 49.2 |
| 3 | 32.7 |
| 4 | 37.0 |
| 5 | 77.2 |
| 6 | 62.8 |

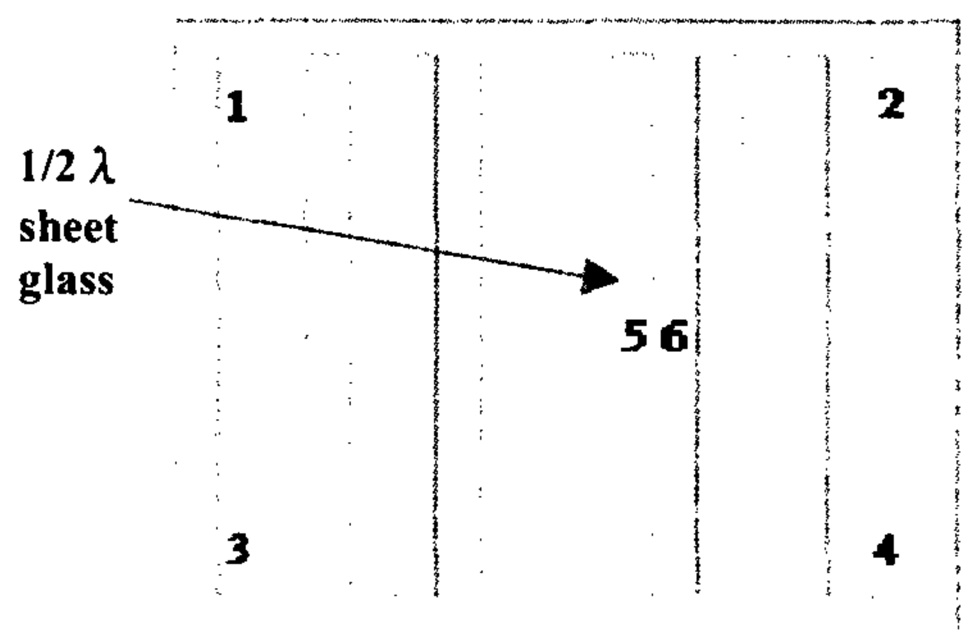


Fig. 7 The measuring points on the PS Converter.

## 3. Conclusion

The LCOS TV is regarded as a quite potential application for the projector industry in the world. However, the design and manufacture of the optical engine is far from easy. This new type optical engine with LMS kernel was improved to get a performance image quality and solve the manufacturing method. To ensure the quality of the end product LCOS-TV is an important issue in the future.

## 4. Reference


[1] C.R. Ou, W.T. Lee, C.F. Yang, H.S. Lin, Y.L. Wu and J.C. Yoo, "*Experiments on thermal induced effect of PBS for LCOS system,*" SID Digest'01, pp926-929, (2001).

[2] G.H. Ho, W.T. Lee, C.C. Lin, H.Y. Lin and J.C. Yoo, "*The color performance of LCOS micro display under temperature variation in projection display system,*" ASID/IDW'01, pp1335-1338, (2001).

[3] LightMaster Systems, Inc. Test Report, (2004).

[4] C.N. Mo, C.L. Liu, C.J. Lin, S.M. Wu, H.Y. Chen," New type LCOS optical engine," International projection conference (April 1-3, 2004), Beiging, Chia, pp99-102, (2004).