Influence of Parasitic Capacitance on the Measurement of CCFL & EEFLs

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Abstract

The measurement technology of the electrical and optical properties of CCFL and EEFL for LCD-BLU is investigated. The lamp current and voltage are affected by the leakage of parasitic capacitance. The methods using the photometer and the integrating sphere are compared to determine the lamp efficiency.

1. Introduction

The parasitic capacitor is generated by the measuring instruments itself, electric lines, and the metal frames when measuring the electrical and optical properties of the backlight unit (BLU). It has a large influence on the measured values of the electrical and optical properties for the lamps of CCFL and EEFL because the lamps are operated with high frequency of AC 50 ~ 100 kHz and high voltage of several kV. Therefore, the measuring condition for minimizing the leakage current is very important.

It was investigated the relations between the luminous flux and the luminance for a lamp. The total flux of the light from a lamp was measured by using the integrating sphere and the luminance was measured by using the luminance meter.

The purpose of this study is to suggest the standard of the electrical and optical measuring technique and reduce the measuring error.

2. Experiments

2-1. Evaluation of Electrical Properties

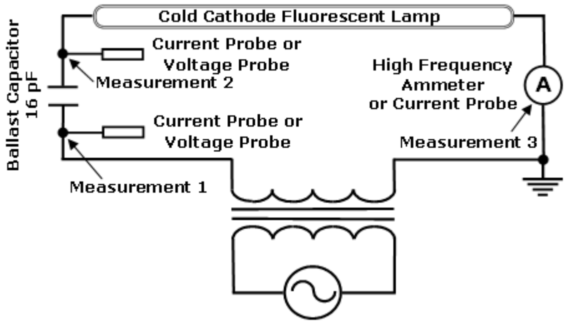
2-1-1. Output Current

In measuring the electrical and optical properties of a lamp, it was investigated how much the measured values depend on the position of the current probe. For this experiment, it was set so that one side of a lamp was applied with high voltage and the other was grounded, as presented in Fig.1. The current probes were installed on the high voltage side and the grounded side of the lamps of CCFL and EEFL. In case of CCFL, the point between the ballast capacitor of inverter and the lamp was also investgated. The CCFL used in the experiment had a length of 669 mm, the outer diameter of 4 mm and the inner radius of 3 mm. The EEFL had a length of 738 mm, the outer diameter of 4 mm and the inner radius of 3 mm.

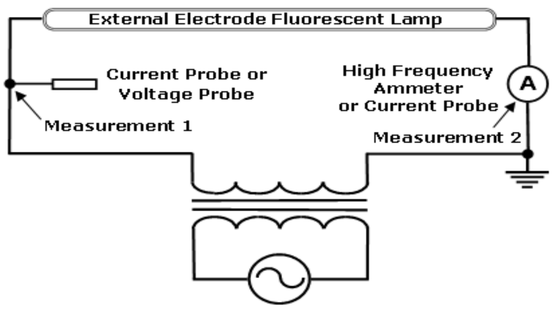
Table 1 shows the measurement results of the input current, luminance and output current according to the positions of the probe. The input voltage of CCFL and EEFL were fixed with 7.4V and 7.2V, respectively. Then the input current and the luminance showed the similar values for all positions of current probe except the position 2 of CCFL.

Table 1. Current Measurements at various points of current probe

lamp	position	input current [A]	luminance [cd/m^2]	output current [mA]
CCFL	1	0.89	10,758	7.178
	2	0.73	8,349	5.860
	3	0.85	10,678	4.480
EEFL	1	0.89	10,710	7.140
	2	0.88	10,573	3.655



(a) CCFL



(b) EEFL

Figure 1. Positions of measuring probes to measure voltage and current when CCFL and EEFL is operated by AC.

If comparing the output current measured at the high voltage side (positions: CCFL-1, EEFL-1) with that of the low voltage(CCFL-3, EEFL-2) side, it was found that there were significant differences. Despite the input currents and the luminances were kept as similar values, the output current at the high voltage side was measured about 3.5mA higher as much as twice than the low voltage side. The differences in currents at the high voltage and at the grounded sides are originated from the leakage of the currents.

The output current, input current and the luminances measured at the position 2 of CCFL were much different from those of other positions. The large difference of luminance of 2,000 cd/m^2 says that the current probe has a large electrical influence on the lamp system. The measurement at the position 2 shows very inaccurate result.

So when measuring the output current of lamps at the backlight unit, the current probe should be always installed at a fixed reference position which the measurement error is minimized. From the results of the above experiment, it is desirable that we take the grounded side as the reference position rather than high voltage side. The measurement at the grounded side includes the environmental conditions and effects of the measuring system including, for example, all leakage currents between the lamp and the frames of the backlight.

2-1-2. Measurement of Voltage

It was also tested whether the position of a voltage probe had an influence on the measured value of voltage. For this experiment the voltage probes were installed on the same positions of the high voltage side as those of the current probe in Fig.1. The model name of the high voltage probe was Tektronix P6015A. The input voltage was set to 7.7V for CCFL and 7.5V for EEFL. The output current was measured at the grounded side with high frequency ammeter. Table 2 shows the measured values of the voltage, luminance and output current.

Table 2. Measurements according to various positions of voltage probe

lamp	position	voltage [V]	luminance [cd/m^2]	output current [mA]
CCFL	no probe	-	10,092	4.7
	1	1,570	15,083	7.2
	2	850	0	0.5
EEFL	no probe	-	9,845	4.0
	1	1,533	12,333	4.5

The results show that the lamp's luminance and output current greatly differed whether the voltage probe was installed or not. In case of CCFL, the voltage measured at the position before the ballast capacitor was very much different from the voltage measured at the position after the ballast capacitor. Especially, the lamp did not even discharge when installed the voltage probe at the position 2. The results show that the installation of the voltage probe bring a great perturbation on the lamp system. In order to measure the voltage with the voltage probe it is desirable to measure at the condition of a constant luminance by adjusting the output current whenever measuring the voltage. And the voltage probe should be installed only when it is necessary.

2-1-3. Influence of Parasitic Capacitor

It was experimented the dependency of the output current on the lead wire. The output current of EEFL were measured differently according to the length of the lead wire at the high voltage side or the position of the probe. In this experiment, the current at high voltage side was measured by current probe while the current at the grounded side was measured by high frequency ammeter. The length of the lead wire was ranged from 100 mm to 300 mm and it was measured at every 20 mm or 30 mm interval between a lamp and an inverter. The current at the grounded side was fixed to 4 mA at every measurement, and then the luminance of the lamp's luminance was almost 10,000 cd/m^2.

Fig.2 shows that the currents measured at a near side of a lamp were smaller than those at a near side of an inverter. The difference of currents measured at an inverter and at a lamp was about 0.8 mA in the case of 100mm length of lead wire. The difference was about 2 mA when the length of lead wire was 300 mm. It shows that there was voltage drop along the lead wire. The reduction of current due to the voltage drop along the lead wire was about 0.007 mA per 25 mm. Therefore, it is desirable that the length of lead wire should be as short as possible to reduce the leakage current.

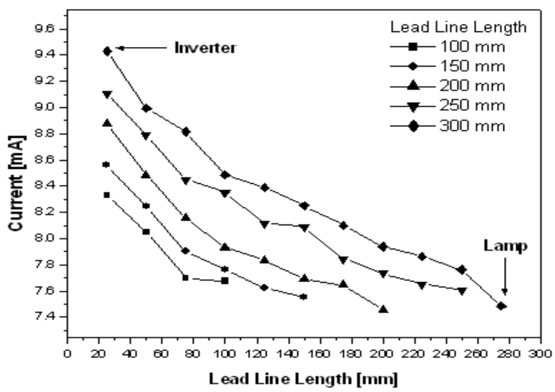


Figure 4. Change the Lead Wire length between Invert and Lamp

To examine the influence of leakage current by metal frame on the electrical and optical properties of the lamp system, a metal frame was placed under the EEFL and grounded. In this experiment, the input current, output current and the luminance were measured while changing the gap between a lamp and the metal frame as much as 10, 5 and 3mm. Table 3 shows the results. The currents were measured at the both of high voltage side and the groundes side: I_1 is the current at the position 1 and it was measured with a current probe, and I_g is the current at the grounded side and it was measured with high frequency amperemeter. As a measurement criteria, the input voltage was adjusted so that the current at the grounded side would be kept with 4.0mA. The experimental results show that as closer the gap between the lamp and the metal frame, as larger the power consumption is and as larger the voltage difference between I_1 and I_g is. And it appeared that there were a difference of the light distribution along the lamp length between the high voltage side and the grounded side when a metal frame placed near under the lamp system. The nonuniformity of the light is getting larger as the gap between the lamp and the metal frame is closer.

Table 3. Electrical and Optical Measurements of EEFL according to the change of gap between a lamp and metal frame

gap [mm]	Input Power [W]	I_1 [mA]	I_g [mA]	Luminance [cd/m^2]	
				High Voltage	Ground
no frame	7.752	7.51	4.0	10,000	10,000
10	8.346	7.84	4.0	13,040	8,603
5	8.960	9.01	4.0	13,680	8,454
3	9.676	10.30	4.0	18,050	8,409

2-2. Evaluation of Optical Properties

2-2-1. Correlation between the luminance and flux of a single lamp

The luminous efficiency η [lm/W] is η=F/W, where F is a flux of a light emission and W is a electrical input power. In order to obtain the luminous efficacy of a single lamp, it needs the evaluation of flux first. The flux of a lamp, F [lm] can be calculated by using a formula, $F=\pi BA$, where B is the luminance of a lamp[cd/m^2] and A is the light emission area of a lamp. So the flux can vary according to the definition of the emission area; What is the emission surface of the lamp? The outer surface of the lamp or the inner surface? Considering the visible rays are emitted from the fluorescent layer, the emission surface should be defined as the inner surface of the lamp. However, since the visible rays are finally emitted from the the outer surface of the lamp, the outer surface can be selected as the emission surface. In this study, in order to determine the criterion, the actual flux obtained using the integrating sphere and the calculated flux from the luminance of the lamp was compared.

2-2-2. Comparisons of Measurement Data

For a CCFL and a EEFL, the luminance and the total flux were measured with a luminance meter and an integrating sphere, respectively. The lamps were operated with high frequency AC as presented in Fig.1. The CCFL used in the experiment had a length of 707 mm, an outer diameter of 3 mm and an inner diameter of 2 mm inner. The EEFL was 692 mm long and had 4 mm outer diameter and 3 mm inner diameter.

Table 4 shows that the comparisons of the flux measured by using an integrating sphere with the flux calculated by a lamp's luminance. There were two kind of values for the calculated flux; the one is calculated using the inner surface of the lamp as the emission surface and the other is calculated using the outer surface. The measured flux was closer to the flux calculated with the outer radius rather the one with inner radius. So the flux of a lamp can be easily obtained by using the luminance and the outer surface area of the lamp without using the integrating sphere.

Table 4. Comparison of flux measured by an integrating sphere and flux calculated with luminance

Lamp type		CCFL	EEFL
Lamp spec.		32"-3 Φ	32"-4 Φ
Input Power [W]		9.39	8.37
Luminance [cd/m^2]		15,460	10,810
Luminous Flux [lm]	measured using integrating sphere	324	281
	calculated using inner radius	215.75	221.49
	calculated using outer radius	323.63	295.32
Efficiency [lm/W]	measured using integrating sphere	34.5	33.5
	calculated using inner radius	22.98	26.46
	calculated using outer radius	34.47	35.28

3. Results and discussions

In order to research the characteristics of CCFL and EEFL for LCD-BLU, the standard measurement conditions should be defined. The measurement quantities of the electrical and optical properties of a lamp may vary according to the conditions of the measuring system. This study examined the variations of the electrical and optical properties for the lamp system of CCFLs and EEFLs, depending on the position of a probe, the length of a lead wire and the gap between a metal frame and a lamp. And the correlation formula obtaining the flux of a lamp from the luminance of a lamp.

When measuring current, a current probe was generally used, in which the measured current were different depending on the position of a probe. The present study shows that the current probe installed at the grounded side have a lower measurement error than the one installed at the high voltage side.

The installation of the voltage probe brought a large electrical perturbations on lamp system, and the luminance and the output currents were distorted. In order to measure the voltage with the voltage probe it is desirable to measure at the condition of a constant luminance by adjusting the output current whenever measuring the voltage.

It was investigated that there was a voltage drop along the lead wire. So it is desirable that the length of lead wire should be as short as possible to reduce the leakage current.

If a metal frame was placed near the lamp system, it influenced on the electrical and optical properties by the parasitic capacitor between the frame and the lamp. The closer the gap between them became, the larger the leakage current became.

It was analyzed the correlation between the flux measured by using an integrating sphere with the flux calculated by the luminance of a lamp, So it was shown that the flux of a lamp can be easily obtained by using the luminance and the outer surface area of the lamp without using the integrating sphere.

The purpose of this study is to suggest the standard measurement conditions for the electrical and optical properties in order to reduce the measuring error.

4. Acknowledgments

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5. References

(1 line gap)

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