Considerations for error factors in four measurement systems determined in JEITA standard ED2523 (Measuring methods for matrix reflective LCD modules)

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Keywords : Measurement accuracy, Reflectance, Error Factors

Abstract

ED-2523 (Measuring methods for matrix reflective LCD modules) was published by JEITA (Japan Electronics and Information Technology Industries Association) in 2001. Since then, round robin tests had been done and the accuracy of measurement values had been discussed. In this paper, considerations for error factors in four measurement systems are showed.

1. Introduction

There are many systems to measure reflectance of reflective LCDs and transflective LCDs. The reason is that the reflective characteristics of reflective LCD modules strongly depend on illumination environment. This environment are various at any place either outdoors or indoors. Because it is impossible to evaluate reflective characteristics of reflective LCD modules by measuring one condition, JEITA committee standardize 4 illumination conditions, and published the standard of reflective measurement method as ED-2523. However, it is difficult to assure good measurement accuracy relative to measuring transmissive LCDs, particular attention should be paid.

2. Experimental

To make clear error factors, our project group established and started investigation in 2002. At first, the round robin test (RRT) was conducted by measuring two PDAs with participation of 12 companies. The next, the 2nd RRT was implemented by measuring "test sample plate". This plate is composed of aluminium layer, diffuser and glass substrate. The reason this plate was measured in this test is to eliminate influence

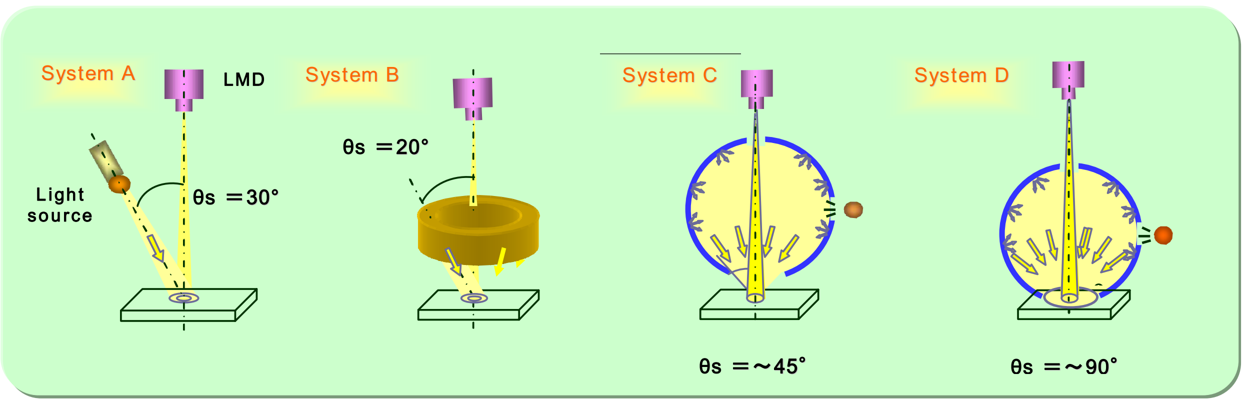

Fig. 1 Illumination conditions of four measurement systems standardized in ED2523. Θs: Incident light angle, Θ_R: Light measuring angle, Θ_R=0°

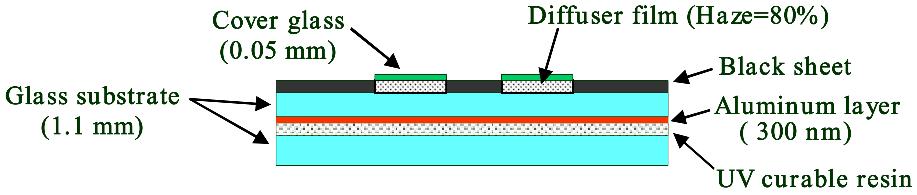

Fig. 2 Structure of Test sample plate

the inclination of sample. Because bottom of the articles mounted LCD modules are not flat, the reflective characteristics are significantly influenced in case of the sample inclined. From the results of these two RRTs, error factors of the four measurement systems became clear.

3. Results and discussion

3-1. Standard measurement system A Directional illumination system

This method is that a light source illuminates a LCD modules with a parallel beam from a specific incident angel and a light modulating device (LMD) received the reflection light from the panel at a specific reflection angle. ED-2523 defined the measuring conditions as θs =30° (at 12 o'clock azimuth), θ_R=0° (normal direction against LCD surface) except for viewing angle measurement. Because these angles were widely used, the configuration was selected. In this system, accuracy of incident light angle and light measuring angle are the most effective error factor. Figure 3 shows the light source angle dependency of reflectance in the case light measuring angle θ_R=0°. In order to assure the measurement error within ±5%, the accuracy of incident angle have to be controlled within ±0.4 degree. Similarly light measuring angle dependency of reflectance were measured. The result is the same as Figure 3. In order to assure the measurement error within ±5%, the accuracy of incident angle have to be controlled within ±0.4 degree similarly. Before these experiments were started, it was confirmed that sample stage did not incline against standard level of this measurement system by using optical flat Al mirror. These results were obtained in case the measurement sample was the test sample plate. The reflective characteristics of actual LCD modules are different from each other. It is important to know the influence of angular accuracy to each measuring sample.

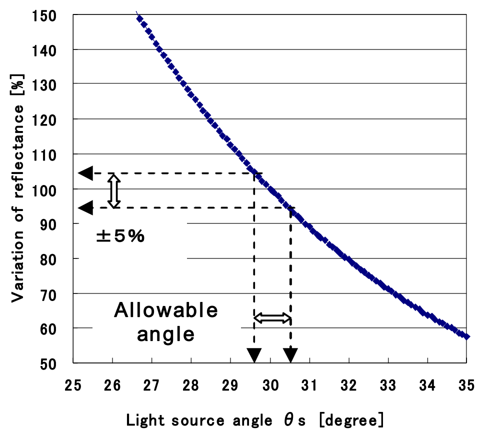

Fig. 3 Incident light angle dependency of reflectance
Measurement conditions: Light source angle θs = 25~35 deg (step 0.1 deg) , Light measurement angle θ_R= 0 deg.
Measurement sample: test sample.

3-2. Standard measurement system B Ring - light illumination system

In this system, ring-shaped light source illuminates the sample and reflectance is measured by LMD placed above center of the ring. The illumination light is a diffused light. However, the flux falling on photometer is specular reflected lights from a LCD module. Because this illumination is equal to the one that parallel flux is illuminated from all the directions, the angle accuracy of both incident angle range and illumination angle are the most effective error factors. The incident light angle θs is the angle based on LCD normal angle and illuminating part of ring-shaped light source. ED2523 defines the measuring conditions as θs=20°, and light measuring angle 0°. These are defined as it is widely used. Figure 4 shows incident light angle dependency of reflectance about a standard white plate and a test sample plate. This measurement was done with ring light source which diameter was φ=58mm. The reflectance are showed in relative values. As seen from the figure, the reflectance variation of a standard white plate is greater than that of a test sample plate. Because of these results, it is necessary to pay attention the accuracy of incident light angle as measuring a standard white plate more than as measuring actual LCD modules. Examples are showed in figure 5. These results are incident angle dependency of reflectance of test sample plate. In this experiment one is the result of reflectance measurement with

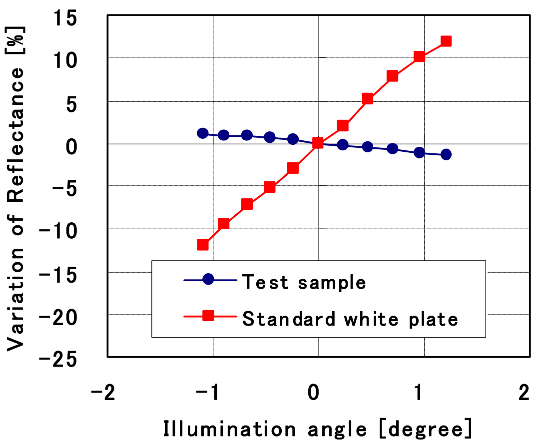

Fig. 4 Illumination angle dependency of reflectance. θ_S=20 degree.

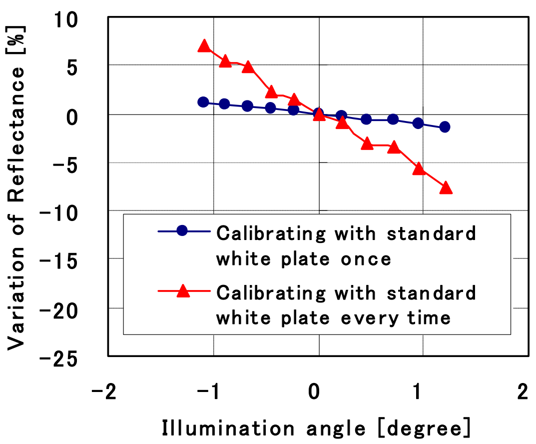

Fig. 5 Illumination angle dependency of reflectance.
Sample: Test sample. θ_S=20 degree.

changing illumination angle after one reflectance calibration with standard white plate, and another is reflectance measurement after reflectance calibrating by standard white plate in every measurement. In the former one, the measuring system position is fixed and only sample height changed as illumination angle error must be checked. The latter one assumed the case of daily measurement that the measuring system position was adjusted in every measurement. As seen from this figure, the reflectance error of the latter is greater than that of the former. For the latter measurement, the illumination angle error has to be controlled within 0.7° in order to make the reflectance error within ±5%. This angle accuracy can be achieved by which the distance between ring-light source and a measuring sample is within 80±3mm.

3-3. Standard measurement system C Conical illumination system

In this system, either integrating sphere or conical light source illuminates the sample and measure the reflection from LCDs by LMD through the measuring port above the light source. ED2523 defines the aperture of light source θs as 45° and light measuring angle 0° seen from sample side. Error factors of this system are aperture angle of the measuring port and incident angle. A precise description about the latter factor is written in ED2523. Figure 6 shows the results of incident angle dependency of reflectance by using test sample plate. The allowable illumination angle error is within ±1.5° in order to control the measuring accuracy of reflectance within ±5%. The error varies depending on the reflective characteristics of an actual LCD module, however, the most effective error factor is angle of incident light. The angle accuracy depends on the distance between an aperture of illumination light source and a LCD modules, and the parallelization degree between exit port of light source and sample surface. For example, assuming the angle accuracy θ=45°±1.5° with light source aperture φ50 mm, the illumination distance should be within the range of 25 ± 1.3 mm. If an aperture of light source is narrow, precise distance accuracy is required.

3-4. Standard measurement system D Hemispherical illumination system

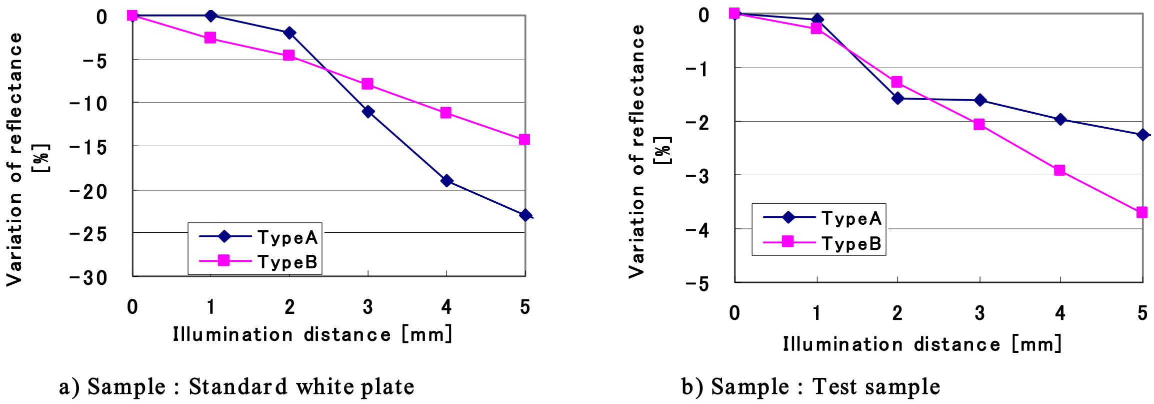

Fig. 7 Illumination distance dependency of reflectance in two different hemispheres.

A light source evenly illuminates a LCD module from all directions and a LMD receives the reflection of normal direction against a LCD module. This is one type of system C, which diffusive light source is attached to a LCD surface. In this system, hemisphere is widely used as light source. Because, it is easy to make the slit for measuring of viewing-angle characteristics. In arrangement D, angle of illumination light (θs), uniformity of illumination light and aperture angle of measuring port are important error factors.

Figure 7(a) and figure 7(b) show the measurement results of standard white plate and test sample with 2 different hemispheres, changing illumination distance. The aperture size of these hemispheres are both 40 mmφ. As seen in figure 7(a), the reflectance becomes low with the illumination distance becomes wide i.e. the θs becomes narrow, because illumination light from wide angle can not reach a standard white plate. On the other hand, the reflectance of test sample slightly changes with increasing illumination distance (d) as shown in figure 7(b). For this reason, the reflective LCD module has almost no gain in wide viewing angle, for example over 80 degrees. Thus the illumination distance for measuring standard white plate have to be set more than for measuring reflective LCD. It is required to set the illuminating distance within 2 mm in case of hemisphere A and 1.5 mm in case of hemisphere B to ensure the measurement error within ±5%.

As described above, reflectance of reflective LCD greatly depends on illumination angle. Similarly, uniformity of illumination light intensity strongly affects reflectance value. In case of hemispherical illumination system, multi branched fiber is used as light sources. It is recommend to attached diffuser at the end of fibers for illumination light uniformity. If a small diameter hemisphere has wide illumination aperture, the light flux from fiber might illuminate a LCD surface. In this case, illumination light might be biased wide angle. The reflectance is measured at low level, because reflective gain of a LCD is low against illumination light from wide angle. On the other side, illumination light is biased near LCD normal, the reflectance is measured at high level.

4. Summary

In this paper, we described error factors and special notice should be paid attention when the reflective characteristics of LCD modules were measured in four measurement systems on ED2523. In case any measuring system, it is important that angle accuracy of measurement system and inclination of measuring sample have to be checked at any time. On the other side, manufactures of measurement systems have to know the error factors and have to make measurement systems that users easily can checked the measurement accuracy.

5. References

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