Measuring of the Basic Parameters of LCD Displays

Submitted 27th June 2011; accepted 2nd September 2011

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Abstract:

This article is about realization of the laboratory stand used for measuring parameters of LCD displays. The stand together with additional accessories (spectrophotometer and measuring probes) as well as software allow to measure a wide range of parameters (colour gamut, response time, contrast coefficient and its irregularity, luminance of black colour and its irregularity, luminance of white colour and its irregularity, changes of luminance depending on the viewing angle). This paper also show method and results of measurements of differences in contrast ratio and luminance uniformity between particular pieces of the same model of a display screen (research has been carried out on 5 pieces of the same model of a display). The presented results show that the measured value of the viewing angle may significantly differ from the value provided by producers of displays.

Keywords: *LCD, parameter, contrast ratio, view angle, luminance, measurement*

1. Introduction

This article is about realization of the laboratory stand used for measuring viewing angles of LCD displays. There is a need to build such stands in order to check whether the parameters of displays reflect the ones provided by their producers. ISO norms guidelines as regards tests of displays (ISO 9241-303:2008 "Ergonomics of human-system interaction – Part 303: Requirements for electronic visual displays" and ISO 9241-305:2008 "Ergonomics of human-system interaction – Part 305: Optical laboratory test methods for electronic visual displays") have been used to make sure the results of such research are reliable. The stand together with additional accessories (spectro-photometer and measuring probes) as well as software allow to measure a wide range of parameters (colour gamut, response time, contrast coefficient and its irregularity, luminance of black colour and its irregularity, luminance of white colour and its irregularity, changes of luminance depending on the viewing angle). In this article the construction of a stand has been described, as well as the method of measuring changes of luminance depending on the viewing angles, which is one of the most important parameters in the situation when there are several people looking at a certain screen. This paper also shows the method and the results of measurements of differences in contrast ratio and luminance uniformity between particular pieces of the same model of a display screen (research has been carried out on 5 pieces of the same model of a display). The presented results show that the measured value of the viewing angle may significantly differ from the value provided by producers of displays.

2. Reasons for independent measurement methods

Theoretically all LCD monitors seem to have parameters allowing to use them almost in any application. According to manufacturers specifications LCD monitors have wide view angles (over160^o), contrast ratio at least 500:1, and 16 million colour, so average user should not be able to observe any difference between view angle of TN matrix and PVA or MVA matrix. Measurements used in technical specifications are usually made by LCD matrix manufacturers, not final monitor manufacturers. During such measurement procedure LCD matrices are placed on special platforms with selected light source powered by high quality power supply. Final result is when two different monitors equipped with the same kind of LCD matrix, but different light source and electronics, have different technical parameters.

3. View angle – luminance changes depending on view angle

According to standards maximal view angle is defined for a picture where contrast ratio in central point of monitor drops to value 10:1. However, the picture is distorted while contrast ratio drops to value 100:1, therefore real loss of picture quality is visible at smaller angles. Moreover, some producers accepted 5:1 as maximal contrast ratio to allow them expand theoretical view angle by approximately 20 degrees.

Measurement method

In order to get information about changes in observed picture while moving observer around the monitor, a measurement stand was designed and build. Measurement of view angle is based on contrast ratio factor:

$$CR = \frac{L_{\max}}{L_{\min}} \tag{1}$$

where: L_{max} – maximal luminance display point, L_{min} – minimal luminance display point.

Compatibility of measurement stand with ISO standard

To make our results comparable with values given by manufacturers, an assumptions according to ISO standards was made:

- Optimal distance of monitor observation according to

ISO 9241-303:2008 [1] is between 300 and 750 mm from central point of the screen.
- According to ISO 9241-305:2008 [2]:
  - monitor which is being tested should be isolated from external light sources,
  - measurement device should be placed perpendicular to screen axis, going through centre of LCD matrix, measurements are made every 10 degrees or less,
  - monitor displays 100% white plane,
  - when measurements are done, luminance uniformity of measurement points is calculated using equation:

$$uniformity = \frac{L_{\min}}{L_{\max}} \cdot 100\% \qquad (2)$$

Measurement stand

Digital SLR camera is mounted on a tripod, which allows to change height of camera from lower to upper edge of monitor. Camera with tripod is able to move around the monitor on previously set radius (range ±90˚from perpendicular position to matrix); motion is realized manually. Before measurements, according to ISO-9241-305:2008, few conditions should be fulfilled:
- remove all dust from monitor matrix,
- warm up monitor – luminance is stable after approximately 20 minutes,
- preliminary parallel position of monitor and camera matrices
- monitor calibration with spectrophotometer,
- setting monitor to native resolution (physical matrix resolution),
- external condition in closed premises, humidity 25–85%, temperature 20–50^{o}C, atmospheric pressure 860–1060 hPa.

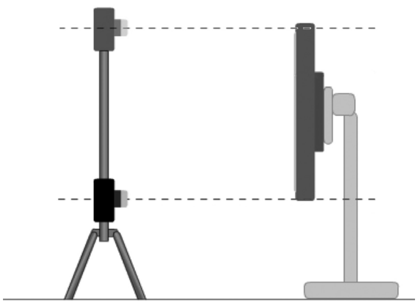

Fig. 1. Measuring stand – schematic diagram

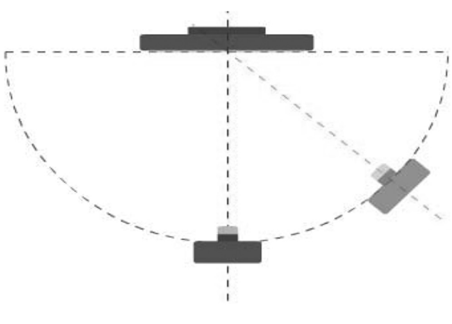

Fig. 2. Measuring stand – measuring angle's range

Measurements

Analysis of acquired data is based on finding points of minimal and maximal luminance, but most important is average luminance of whole matrix (or selected region). Measurements of horizontal and vertical angles were made for 5 monitors (same manufacturer and model), to reveal differences between theoretically identical copies of the same monitor. Charts below show average values of whole monitor matrix.

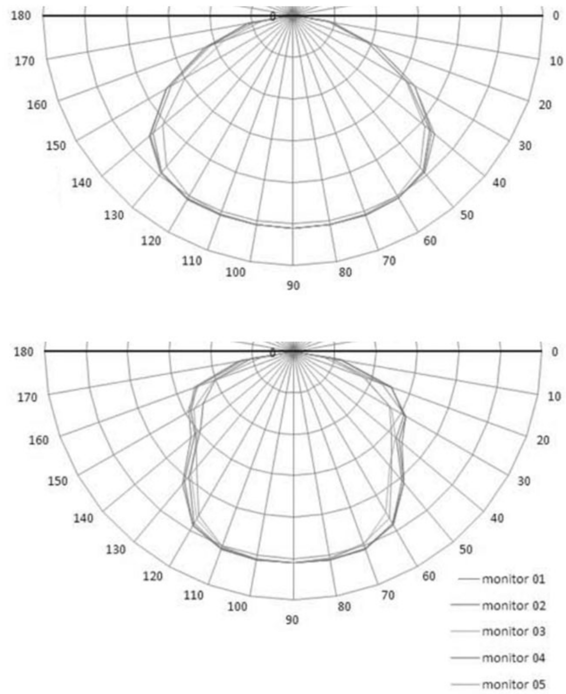

Fig. 3. Chart of the dependence of gray-scale level on horizontal (up) and vertical (down) viewing angle

4. Uniformity of Contrast Ratio

In contrast ratio measurement procedure and its uniformity a set of two checkerboard. In place of white rectangles on one board, black ones are on the second.

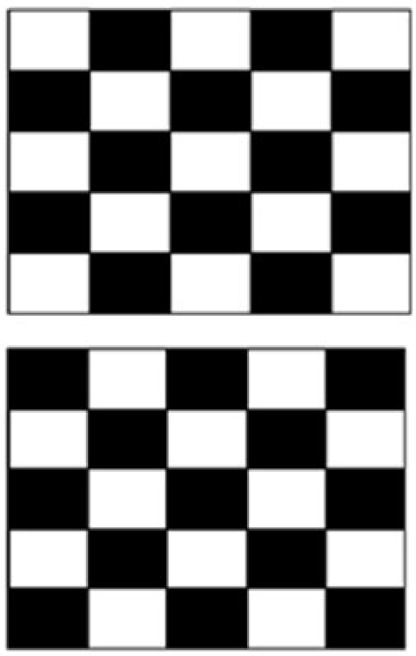

Fig. 4. Test board

Measurements were made using electronic circuit OPT101 consisting of photodiode with trans-impedance amplifier in one structure. Electric current is proportional to light stream. Procedure is simple, but needs accuracy.

First step is to display board on the left, and measure with probe each white field (measurement on centre of rectangle), next step is to display the second board and repeat measurement on the black fields. Results are measurements in 13 points for each board, and measurements were repeated five times to make estimation more accurate and certain.

Measurements

Results in percents show distortion in uniformity of contrast ratio while setting backlight for 100% and 50% for group of 5 monitors (M1-M5).

Tab.1. Contrast Ratio and contrast uniformity difference measurement results

	M1	M2	M3	M4	M5
Param [%]	100	100	100	100	100
Min CR	68,9	67,8	63,8	63,7	58,0
Max CR	127,9	105,5	113,5	115,3	110,3
ΔCR	59,0	37,7	49,7	51,6	52,3
diff. CU	53,8	64,3	56,2	55,2	52,6
	M1	**M2**	**M3**	**M4**	**M5**
Param [%]	50	50	50	50	50
Min CR	57,9	69,9	64,3	63,8	50,0
Max CR	112,3	100,0	105,4	122,2	100,6
ΔCR	54,4	30,1	41,1	58,4	50,6
diff. CU	51,5	70,0	61,0	52,2	49,7

Contrast uniformity:

$$CU = \frac{C_{\min}}{C_{\max}} \cdot 100\% \tag{3}$$

where C_{min} i C_{max} are minimal and maximal measured value of CR.

Significant difference in contrast uniformity is observed, but average value of difference in uniformity is about 50%. It cannot be discussed without looking at results of contrast ratio for whole surface of matrix.

Tab. 2. Contrast Ratio values

	M1	M2	M3	M4	M5
CR	40:1	43:1	46:1	38:1	38:1

5. Conclusions

Measurement stand allow to measure LCD monitor parameters representative for image reproduction quality and comparing to values given by manufacturers. Our research shows that our results of viewing angle, as well as contrast ratio strongly differs from that published by manufacturers in technical specifications. Contrast uniformity and luminance uniformity are parameters that seem to be relevant in describing quality of monitor and are not included in official specifications. Significant differences in uniformity of white luminance are main source of differences in contrast ratio.

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References

[1] ISO 9241-303:2008: Ergonomics of human-system interaction – Part 303: Requirements for electronic visual displays

[2] ISO 9241-305:2008: Ergonomics of human-system interaction – Part 305: Optical laboratory test methods for electronic visual displays.