NEW METHOD OF LCD DISPLAY VIEWING ANGLE DESIGNATION

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Summary: Most people think that LCD monitors are low or zero in radiation. That is not true. The backlighting uses thousand volts for fluorescence and carries an electromagnetic field. Zero radiation LCD monitors use e.g. clear metallic grating in front of the display viewing area. The main goal of this contribution is optical properties analyze of radiation protected and no protected LCD displays. The analyze evaluates the display viewing angle which is one of the most important indicators for graphic information quality in the Human Computer Interface system.

1. INTRODUCTION

Optical properties analyzing of the LCD displays was the main goal of development. We explore one of the basic characteristics of LCD (Liquid Crystal Display) – quality of visual display from the views of customer, which observe display field viewing under various angles.

The experimental place was assembled for achievement of this goal. The measurement and evaluation of display viewing angles have been performed there. The technical solution is shown in Fig.1 and the measured display is shown in Fig. 2. The measurement algorithm of display viewing angles will be described in the next part of contribution. The measurement results and computer processing will be described in the conclusion.

2. DISPLAY VIEWING ANGLE MEASUREMENT

Display viewing angle is one of the most important quality parameters of displaying graphical information. If we use one of the most frequent monitors – LCD, this parameter is unfavourable.

The monitor emitting plain can be skewed at vertical alternatively horizontal direction from frontal visual plain of customer (Fig. 3a, 3b).
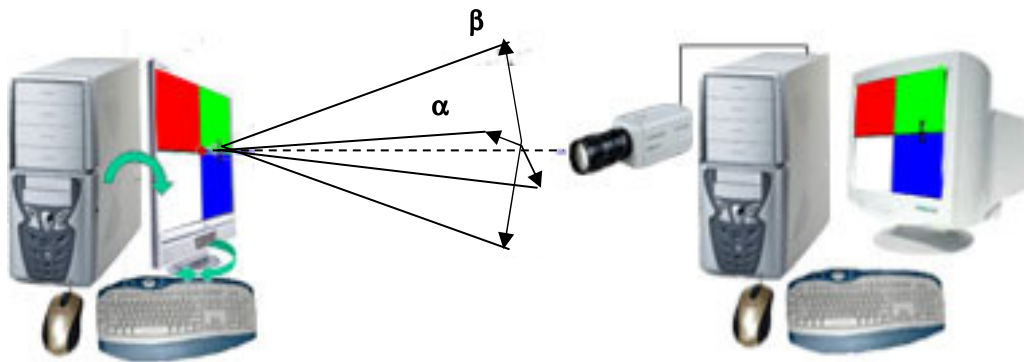
Measure part   Evaluation part

Fig.1 The measuring place configuration for display viewing angle measurement

Fig. 2 Measured LCD display steady in the mechanical support.

How we can see at Fig. 3a, we recognize vertical display viewing angle (α) and horizontal display viewing angle (β) – Fig. 3b.

Definition 1: If relative brightness intensity for measured colour (R,G,B,W) falls under 71% of relative brightness intensity for colour (R,G,B,W) measured when vertical display viewing angle $\alpha = 0$, this value is labelled as critical value of vertical display viewing angle α_{krit} for measured colour (R,G,B,W).

Definition 2: If relative brightness intensity for measured colour (R,G,B,W) falls under 71% of relative brightness intensity for colour (R,G,B,W) measured when horizontal display viewing angle $\beta = 0$, this value is labelled as critical value of horizontal display viewing

angle β_{krit} for measured colour (R,G,B,W).

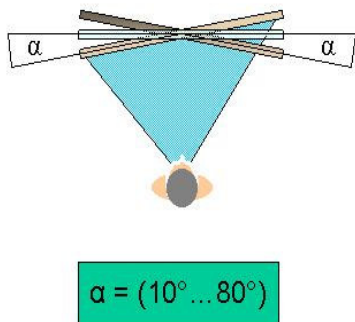Display viewing angle measurement is realized by camera, when the special image is ejected by monitor

$$\alpha = (10°...80°)$$

Fig. 3a Vertical display viewing angle measurement
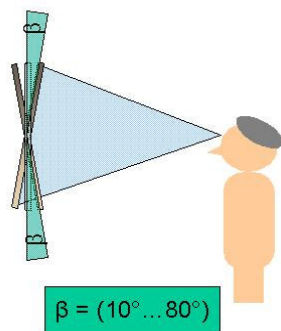

$$\beta = (10°...80°)$$

Fig. 3b Horizontal display viewing angle measurement

and then is scanned by camera. The measured monitor can be deflected in both plains vertical and horizontal.

2.1 Display viewing angle measurement algorithm

The first step of measurement is to line up both plains (monitor plain and camera plain) - $\alpha=0$, $\beta=0$.

The calibration image (Fig. 4) is displayed on the monitor in the second step of measurement. If the monitor and camera plains are not lined up then we calculate the appropriate dimension (1).

$$\left(a \cong \max\left(a'\right)\right) \wedge \left(b \cong \max\left(b'\right)\right) \\ \Leftrightarrow \left(\left(\alpha = 0\right) \wedge \left(\beta = 0\right)\right) \quad (1)$$

where a, b are calibration image dimensions on the measured monitor

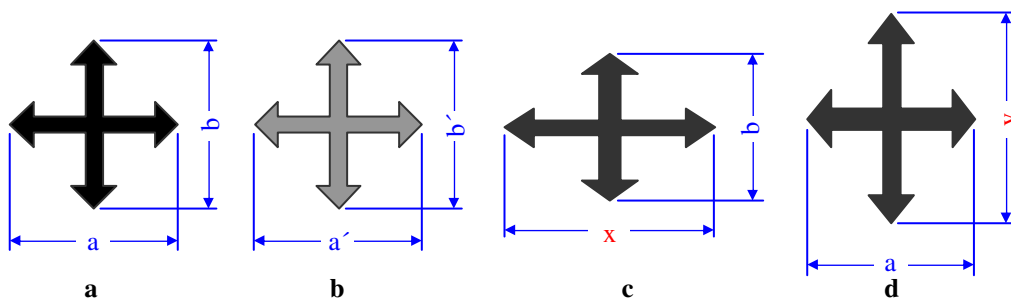a´, b´ are dimensions measured by program on the monitor with scanning camera

$$\left(x = \frac{a}{\cos\alpha} \cong \max\left(a'\right)\right) \wedge \left(b \cong \max\left(b'\right)\right) \quad (2)$$

$$\left(y = \frac{b}{\cos\beta} \cong \max\left(b\right)\right) \wedge \left(a \cong \max\left(a'\right)\right) \quad (3)$$

where x, y are dimensions of displayed calibration image for various display viewing angles ($\alpha \neq 0, \beta = 0$) and ($\alpha = 0, \beta \neq 0$).

This calibration image corresponds to desired values of vertical angle α or horizontal angle β. The testing image RGBW is scanned after calibration. The algorithm is at flowchart in Fig. 5.
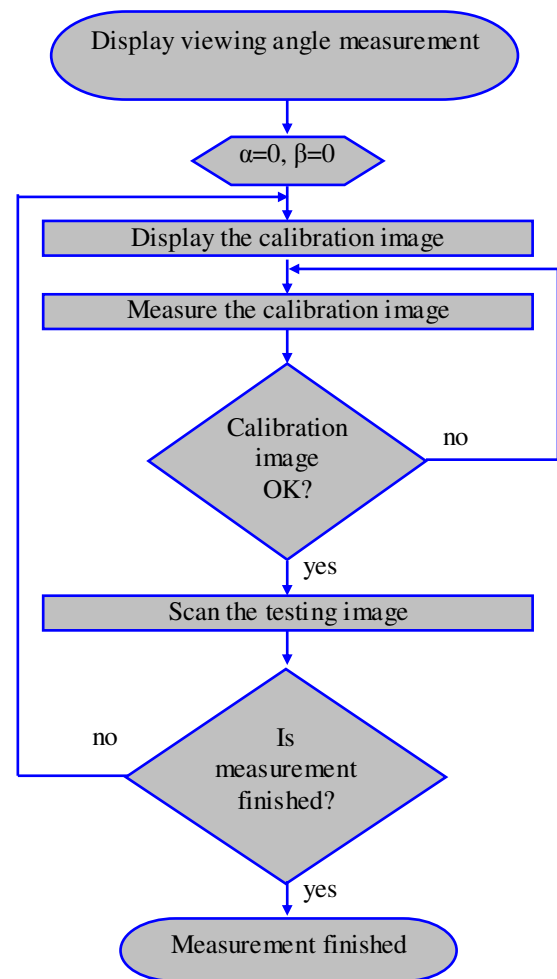

Fig. 5 Flowchart for display viewing angle measurement

*Fig.4 Calibration image at the emitting side (**a**: $\alpha=0,\beta=0$; **c**: $\alpha\neq0,\beta=0$; **d**: $\alpha=0,\beta\neq0$) and the receiving side (**b**: $\alpha=0,\beta=0$)*

3. APPLIED RESOURCES AND RESULTS OF DISPLAY VIEWING ANGLE MEASUREMENT

For acquisition of tests and calibrating images we used CCD HITACHI COLOR CAMERA - MODEL HV-C20/C20M with good optics and high quality CCD technology. The images are digitized by special digitizing card Matrox CORONA**.** Interpretation of results was performed by LUCIA, which is product of Laboratory Imaging and LabVIEW, which is product of National Instruments.
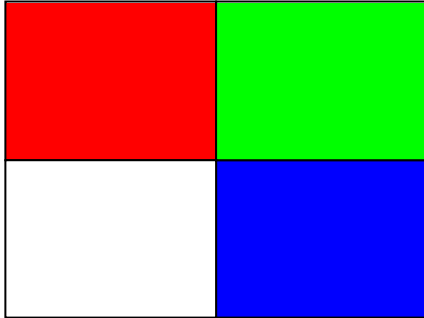
The processing of scanned images was done at

Fig. 6 Scanned image

Count: 65682   Min: 123
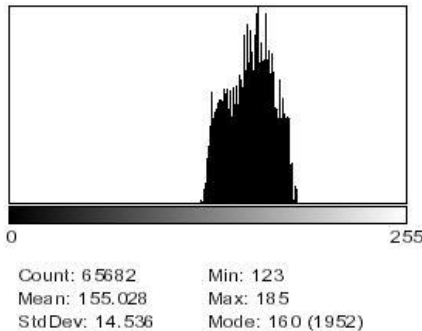Mean: 155.028   Max: 185
StdDev: 14.536   Mode: 160 (1952)

Fig. 7 Histogram of scanned image

some steps. The first of all we take out appropriate color (R, G, B or W) from the centre of scanned image (Fig. 6). Then histogram (Fig. 7) was created for chosen color. The mean value was computed and compared with the value of image α=0, β=0.

The VÚVT display prototype PCS (Protected Computer System) is hardiness display. This PCS display has clear metallic grating in front screen-glass. Optical and electromagnetic radiations are suppressed with clear metallic grating. It makes worse people's optical comfort. The goal of our measurement was to consider clear metallic grating effect to people's optical comfort.

Measurement was realized on two displays (17.0" SXGA Color TFT-LCD monitor M17EN05 and 20,1" LCD monitor Neovo X-20AV). We performed two measurements for every display (with clear metallic grating and without clear metallic grating). The results of measurements are in Tab.1 and Tab.2.

The graphical interpretation of measured results for display viewing angle measurement is in next part of chapter.

The critical values of vertical display viewing angles for 17.0" SXGA Color TFT-LCD monitor M17EN05 without and with clear metallic grating are at Fig. 9 and Fig. 11. The critical values of vertical display viewing angles for 20,1" LCD monitor Neovo X-20AV without and with clear metallic grating are at Fig. 10 and Fig. 12.

These characteristics can be determined according to the definition 1 and 2 from graphical representation and the results are in Tab.1 and Tab.2.

Critical display viewing angle	*without clear metallic grating*				*with clear metallic grating*			
	R	G	B	W	R	G	B	W
vertical - α_{krit} [^{O}]	70	64	54	67	47	45	40	45
horizontal - β_{krit} [^{O}]	53	53	40	66	29	24	26	36

Tab. 1 Critical display viewing angle for 17.0" SXGA Color TFT-LCD monitor, model M17EN05, AU Optronics, Inc.

Critical display viewing angle	*without clear metallic grating*				*with clear metallic grating*			
	R	G	B	W	R	G	B	W
vertical - α_{krit} [^{O}]	79	80	76	80	68	67	66	67
horizontal - β_{krit} [^{O}]	78	75	77	79	63	62	61	63

Tab. 2 Critical display viewing angle for 20,1" LCD monitor, model Neovo X-20AV

Angle comparison:	R	G	B	W
vertical - α_{krit} [^{O}]	- 23	- 19	- 14	- 23
horizontal - β_{krit} [^{O}]	- 24	- 19	- 14	- 30

Tab. 3 Difference of critical display viewing angle with and without clear metallic grating for 17.0" SXGA Color TFT-LCD monitor, model M17EN05, AU Optronics, Inc

Angle comparison:	R	G	B	W
vertical - α_{krit} [^{O}]	- 11	- 13	- 10	- 13
horizontal - β_{krit} [^{O}]	- 15	- 13	- 16	- 16

Tab. 4 Difference of critical display viewing angle with and without clear metallic grating for 20,1" LCD monitor, model Neovo X-20AV

4. CONCLUSION

Values of display viewing angles, which are defined as optical characteristics of LCD displays, are defined basically from minimum values of contrast. This measurement algorithm, which is derived from the properties of RGB model, offers complexion point of view on LCD displays and its display viewing angles. The comparison results are in Tab. 3 and Tab. 4. In this table are results for comparison of critical display viewing angle with and without radiation protection in vertical and horizontal position for both measured displays. We can say the clear conclusion: if we increase display viewing angle the colours saturation is decreased and this attribute has negative effect on people's optical comfort.

Acknowledgement

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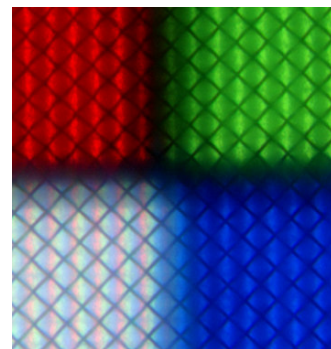[5] Klinger, T.: Image processing with LabVIEW and IMAQ Vision, Prentice – Hall International, Inc. 2003

Fig. 8 Display with clear metallic grating
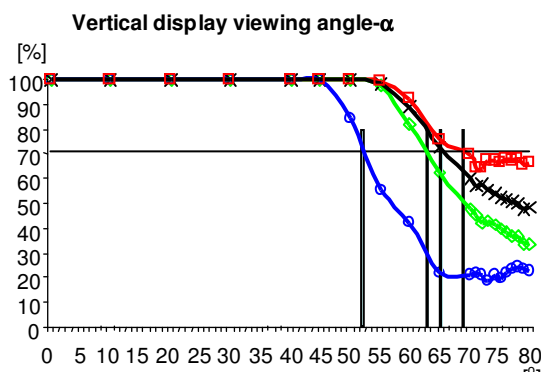
Monitor without clear metallic grating

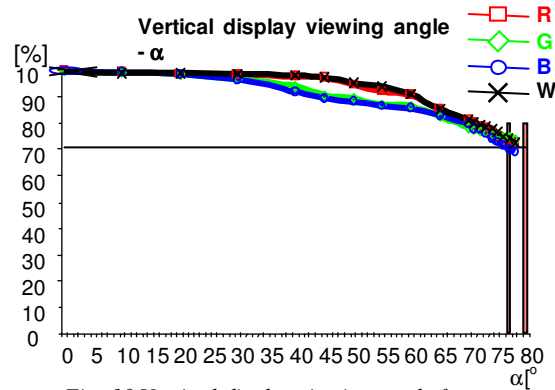*Fig. 9 Vertical display viewing angle for 17.0" SXGA Color TFT-LCD monitor, model M17EN05, AU Optronics, Inc*

Fig. 10 Vertical display viewing angle for 20,1" LCD monitor, model Neovo X-20AV

Monitor with clear metallic grating

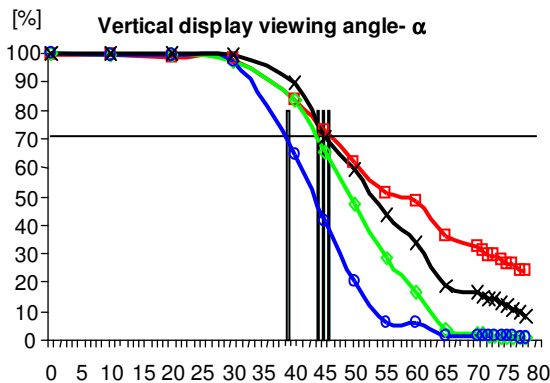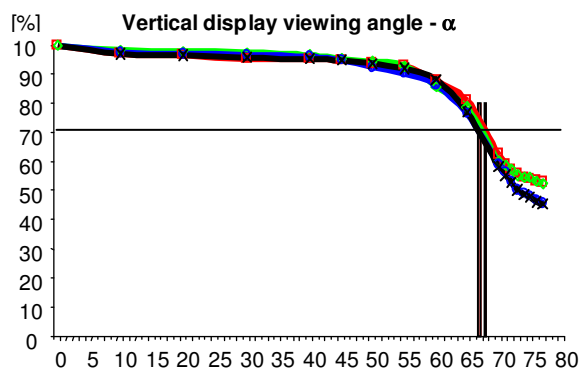*Fig. 11 Vertical display viewing angle for 17.0" SXGA Color TFT-LCD monitor, model M17EN05, AU Optronics, Inc*

Fig. 12 Vertical display viewing angle for 20,1" LCD monitor, model Neovo X-20AV