Collimated backlight for liquid crystal displays

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1. Introduction

In this work, a collimated backlight design is presented. Traditionally backlights are either direct-lit in which an array of LEDs are directly behind the LC- panel, or edge-lit, in which case there is a light guide behind the LC-panel and LEDs are placed at the side of this light guide. These designs have their advantages and disadvantages but in both cases they emit light under a wide angle.

Using a collimated backlight can however provide several advantages compared to a normal backlight with regards to contrast ratio, transmission, color, 3D-applications and energy consumption. [1,2]

In literature, directional backlights can be found which achieve a degree of collimation in the range of 15° down to 4.9° (full width half maximum values). This collimation is however only achieved in the horizontal direction, while the collimation in the vertical direction is still close to 20° or more. [1,2,3]

2. Design of the collimated backlight

The design of the backlight uses a grid of LEDs, as in a direct-lit backlight. The light of these LEDs are collimated by using 2 consecutive lenses. The first lens is placed close to the LED. Its goal is to collect all the light of the LED and emit it under a narrower angle. The second lens is bigger and is used to collimate the light further. The design was simulated and optimized by means of the Optic Studio software package.

2.1 Used components

The chosen LED is sold by OSRAM (model: LUW GVCP) and ray-files for this LED are available online, which have been used in the simulation.
To keep the design "prototype-friendly", it has been decided to use a standard aspheric lens as the first lens. The second lens is a freeform lens which has been optimized for use in combination with this LED and the aspheric lens. In order for the backlight to have a complete illumination plane, these second freeform lenses have been cut into a hexagon and are stacked next to each other in a hexagonal array as shown in fig. 1.

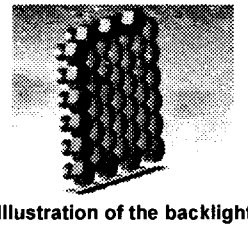

Figure 1: Illustration of the backlight design

2.2. Simulated Performance

The designed backlight shows a uniformity of 73% (at 11mm from the backlight). The hexagonal pattern is visible with a higher brightness in the center and at the edges of each hexagonal lens. The collimation is 4.7° for both vertical and horizontal directions. This angle is defined by the positions where the intensity is reduced to 10% of its maximum.

3. Prototype Fabrication and Results

The LEDs and the aspheric lenses were ordered and the designed freeform lenses were fabricated (printed) by Luximprint. Three frames were built (for the PCB, first- and second lenses) of which the position was tunable in both translation, rotation and tilt with respect to each other (6 degrees of freedom).

As can be seen in fig. 2, the backlight is not uniform and dark gaps are visible between two lenses. When a light diffuser is applied after the second lens, a uniform area is achieved at 8 cm from the backlight. By measuring the size of the beam in function of the distance from the backlight, the collimation is measured to be 8.6° and increases to 10.4° when the light diffuser is used (where intensity is reduced to 10% of its maximum).

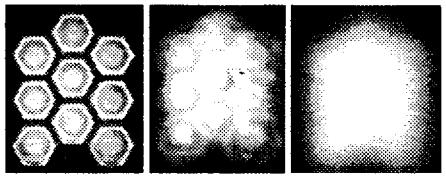

Figure 2: Image of the prototyped backlight at 1cm (left) and 8 cm (middle) from the backlight. The right figure shows the uniformity at 8cm when a light diffuser is used.

4. Acknowledgements

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5. References

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