Digital LED Desk Lamp with Automatic Uniform Illumination Area by Using Two Accelerometers and Halftone Method

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Abstract-- **In this paper, we design a digital LED desk lamp that can adjust the LEDs brightness in the LED array to obtain the uniform illuminated area whenever the user rotates the lamp shade. The system contains three parts: the LED light source, the tilted measurement unit and the control unit. When the user adjusts the position of the lamp shade the system can change the halftone pattern by using the angle difference from the measurement of the two accelerometers to produce a uniform illuminated area.**

I. INTRODUCTION

There are many papers about the extant products on the market that discuss a variety of table lamps with a dimmer control [1], but most use several high-power LEDs with a PWM dimmer to adjust the brightness. This method indeed achieves an efficient adjustment of brightness, but mostly with an overall adjustment of the illumination area which is often concentrated in the middle [2].

The user often adjusts the position shade to change the LED brightness, especially when the lamp shade moves at an angle. If the user is reading the light far away from the center where its brightness will be darker, when he is close to the central part of the light the brightness is too bright. To overcome this disadvantage, in this paper, we present an automatic digital adjustment of the barycenter of the LED desk lamp which is called the halftone digital LED desk lamp (HDL) as shown in Fig. 1. The system is divided into several parts: the digital LED light source, the tilted measurement unit and the microcontroller unit. The digital LED light source uses the halftone method to adjust the brightness. Because we select the digital light source, the illumination area can adjust the brightness. The second part is the automatically tilted measurement unit, a light source which is used when the user changes the height or angle with the desktop.

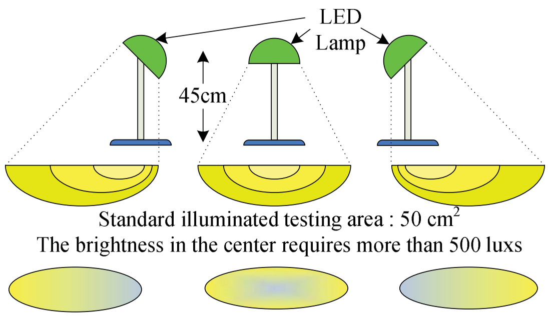

Fig. 1. The relation between the lamp shade rotation angle and the illumination areas

II. ARCHITECTURE OF HDL

Figure 2 shows the HDL system diagram. The left part of Figure 2 presents a digital LED light source, which contains the LED array and LED Driver. The digital light source module can accept control signals from the MCU, respectively, for some LEDs in order to function as an on/off control.

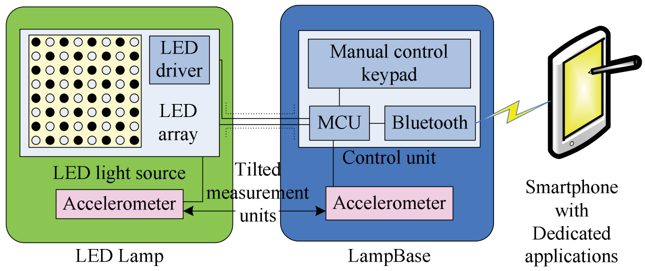

Fig. 2. The halftone digital LED desk lamp system diagram

The tilted measurement unit is used to compare the two accelerometers with each other to obtain the function of the angle difference [3]. According to the definition of Euler's formula, any object in three-dimensional space can be used to represent the three Euler's angles, when the rotation angle displacement of the LED lamp is covered by this method. The main function of the control unit is to select the brightness, to serve as the manual lighting control and to compute the angle between the lamp shade and desktop surface as shown in Fig. 3. If we place the lamp base on a table that has an angle with ground plane the LED lamp may obtain an error of measurement data. By this design two accelerometers, Acc1 and Acc2, are placed in the lamp shade and lamp base to obtain the angle difference to avoid error. When the LED lamp shade has been moved or rotated the tilted measurement unit obtains an angle difference which will be calculated and stored by the MCU.

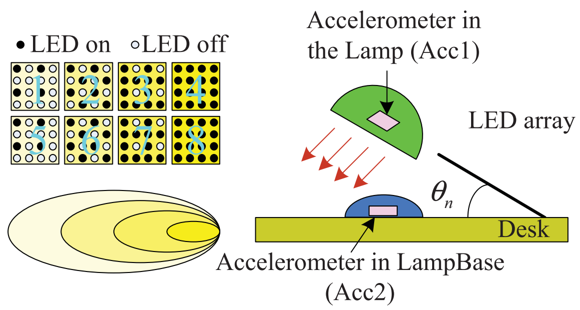

Fig. 3. The oriental halftone pattern and rebuild halftone pattern in eight levels

From the accelerator datasheet, the relationship of the accelerator output voltage is V_O, and the zero degree output voltage V_0. The acceleration values X_g, Y_g and Z_g will be determined by (1).

$$V_O = V_0 + 0.8 \times X_g,\ V_O = V_0 + 0.8 \times Y_g,\ V_O = V_0 + 0.8 \times Z_g \quad (1)$$

When the lamp shade moves the accelerometer in the lamp shade (Acc1), the x, y, z axis displacement of the three angles on the variation of the angle is determined by (2).

$$\theta = Sin^{-1}\left(X_g\right),\ \ \rho = Sin^{-1}\left(Y_g\right),\ \ \vartheta = Cos^{-1}\left(Z_g\right) \quad (2)$$

The θ, ρ and ϑ are the angle of the three axis which can be calculated by using the acceleration value X_g, Y_g and Z_g from the measurement of the Acc1. Normally the lamp base is heavier, so the amount of changes in the rotation lamp shade does not produce any difference. If we take the three angles value which is obtained from rotating the lamp shade and subtracting a trace angle value that is obtained from the accelerometer in the lamp base (Acc2), by using this procedure we obtain the actual angle relative to the base of a LED lamp, and we then use a different halftone pattern to adjust the brightness.

Fig. 4 shows the flowchart of the major functions, when the user turns on the LED lamp. If the power-on button is pressed the system will obtain an interrupt signal and check either the “increase brightness”, the “decrease brightness” or the “Turn off” function. The system will turn on the LED depending on the halftone pattern which will be read out from the MCU memory or the register. When the user rotates or moves the lamp shade, the MCU will calculate the angle difference between Acc1 and Acc2, θ_n and then will rebuild the halftone patterns in keeping with the sensing value.

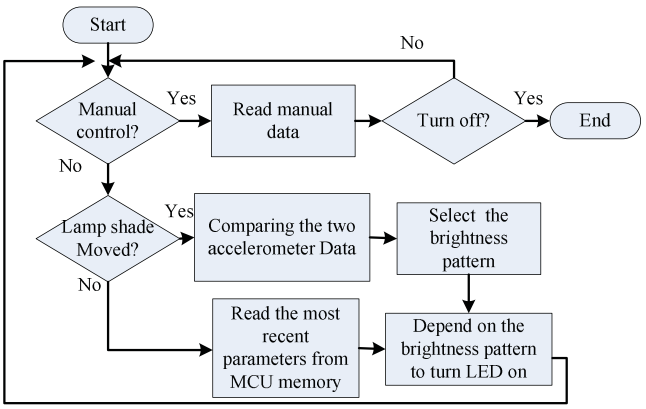

Fig. 4. The HDL flowchart

III. IMPLEMENTATION RESULTS

In the experiment, we fixed two axes (y and z) and adjusted the measured brightness at 50% which results in halftone level 4 on the X-axis in three different angles. We set the brightness on every single LED matrix from level 1 to 8. Level 0 is completely dark and the level 8 is the brightest. The measurement result is summarized on Table I.

We measure the power consumption of MCU and the accelerometer that is almost within a fixed angle value. Because the LED lamp brightness can be adjusted from a lowest to a highest brightness, there will be different power consumptions. The measurement results are shown on Table II.

TABLE I
THE ANGLES AND HALFTONE LEVELS OF THE MEASUREMENT RESULTS

Angle of Axis X	LED matrix no. 1 and 5	LED matrix no. 2 and 6	LED matrix no. 3 and 6	LED matrix no. 4 and 8
15°	Level 5	Level 4	Level 2	Level 2
30°	Level 3	Level 3	Level 2	Level 2
45°	Level 2	Level 4	Level 1	Level 1

TABLE II
THE POWER CONSUMPTION OF EACH PART OF THIS DESIGN

Power Consumption	Min.	Max.
MCU	4.459 mW	4.590 mW
Accelerometer	1.384 mW	1.384 mW
Bluetooth Module	12.880 mW	85.488 mW
LED Lamp (with LED Driver)	1851.123 mW	8186.763 mW
Total	1869.846 mW	8278.225 mW

The comparison results with other designs are shown on Table III. When we rotate the LED lamp shade in different degrees, the system will automatically compensate the illumination. The total power consumption, which is 8.2 W, includes the LED array with the driver, the MCU, the tilted sensor and the communication module.

TABLE III
COMPARISON WITH OTHER DESIGNS

	Design A [1]	Design B [2]	This Design
Brightness Adjustable	3 Steps	5 Steps	8 Steps
Max. Brightness	1238 luxs	1754 luxs	1600 luxs
Wireless Remote Control	No	No	Yes
Uniform Illuminated Area	No	No	Yes
Max. Power Consumption	8 W	9 W	8.2 W

IV. CONCLUSION

To adjust the brightness of a LED desk lamp, as this design uses the measurement of the accelerometers to calculate the angle of the LED lamp, the brightness will be automatically corrected by selecting the different digital halftone patterns to achieve the desired uniform brightness.

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