

SYSTEM AND METHOD FOR GENERATING LIGHT PATTERNS

5 FIELD OF THE INVENTION

The invention relates broadly to systems and methods for generating light patterns.

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BACKGROUND OF THE INVENTION

There are various desktop light emitting diode decorative displays, such as a routine running light pattern from a light emitting diode (LED) illuminating through a glass or a crystal ornament, or an external light emitting diode acting as a spot light beam at a glass or a crystal ornament. The common features of the conventional light emitting diode decorative displays are either that the luminance patterns are pre-determined at the factory or that the luminance light source is external at a distance to the decorative display. They may have a few routines on the luminance pattern but they are predictable. On the other hand, when the light emitting diode light source is built-in together with the decorative display, the decorative display cannot be replaced with a different decorative display of choice. The flexibility on the location of the decorative display is further hindered in the case when the installation of a distance spot light source is required.

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A need therefore exists to provide a system and method that address at least one of the above problems.

30 SUMMARY OF INVENTION

In accordance with a first aspect of the present invention, there is provided a system for generating light patterns, the system comprising a noise source; an analog electronic circuit; and a light emitting diode (LED) light source; wherein the

analog electronic circuit converts a signal from the noise source into an input for generating light patterns on the LED light source.

5 The analog electronic circuit may comprise a first amplifier for amplifying the signal from the noise source to a selected voltage range.

The analog electronic circuit may further comprise an envelope detector coupled to the first amplifier for removing high frequency components of the signal from the first amplifier. Preferably, components of the signal that are more than about
10 50 KHz approximately are removed.

The analog electronic circuit may further comprise a second amplifier coupled to the envelope detector for amplifying and shifting the signal from the envelope detector. The second amplifier may be an inverting amplifier. Preferably, peaks of an
15 output signal from the second amplifier are greater than a reference voltage.

The analog electronic circuit may further comprise a voltage comparator coupled to the second amplifier for comparing the signal from the second amplifier with a selected value. The selected value may be equal to a value of the reference
20 voltage. The output signal from the voltage comparator may comprise a binary signal.

The analog electronic circuit may further comprise a resistor-capacitor (RC) network coupled to the voltage comparator for controlling a current input to the LED
25 light source.

The noise source may comprise a white noise generator.

The noise source may comprise ambient noise or music.

30 The system may further comprise an ambient light detector, wherein luminance of the LED light source is dependent on ambient darkness.

In accordance with embodiments of the present invention, there is provided a lighting apparatus comprising the system as described above. Light patterns
35 generated from the lighting apparatus may resemble flame flickers.

In accordance with a second aspect of the present invention a method of generating light patterns, the method comprising providing a noise source; providing an analog electronic circuit; and connecting the analog circuit to the noise source and a light emitting diode (LED) light source; wherein the analog electronic circuit converts a signal from the noise source into an input for generating light patterns on the LED light source.

The noise source may comprise a white noise generator.

The noise source may comprise background noise or music.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

Figure 1 is a circuit diagram of a system for generating light patterns according to an example embodiment;

Figure 2A is a voltage waveform of a white noise signal after a first amplifier according to an example embodiment;

Figure 2B is a voltage waveform of the white noise signal of Figure 2A after an envelope detector;

Figure 2C is a voltage waveform of the white noise signal of Figure 2A after a second amplifier;

Figure 2D is a voltage waveform of the white noise signal of Figure 2A after a voltage comparator;

Figure 2E is a current waveform of the white noise signal of Figure 2A passing through a Light Emitting Diode (LED);

5 Figure 3 is a circuit diagram of an envelope detector of Figure 1 according to an example embodiment;

Figure 4 is a graph showing a frequency response characteristic of the envelope detector of Figure 3 according to an example embodiment;

10 Figure 5A is a voltage waveform of an audible sound signal after a first amplifier according to an example embodiment;

Figure 5B is a voltage waveform of the audible sound signal of Figure 5A after an envelope detector;

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Figure 5C is a voltage waveform of the audible sound signal of Figure 5A after a second amplifier;

Figure 5D is a voltage waveform of the audible sound signal of Figure 5A after a voltage comparator;

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Figure 5E is a current waveform of the audible sound signal of Figure 5A passing through a Light Emitting Diode (LED);

25 Figure 6A is a side view of a lighting apparatus comprising the system of Figure 1 according to an example embodiment;

Figure 6B is a top view of the lighting apparatus of Figure 6A without a cover;

30 Figure 6C is a close up side view of the lighting apparatus of Figure 6A;

Figure 6D is a top view of the lighting apparatus of Figure 6A showing position of a switch array;

Figure 7 is a flowchart illustrating a method of generating light patterns according to an example embodiment.

5 DETAILED DESCRIPTION

Figure 1 is a circuit diagram of a system 100 for generating light patterns according to an example embodiment. The system 100 comprises a noise source in the form of a white noise generator 9; an analog electronic circuit 110; and a light
10 source in the form of a Light Emitting Diode (LED) 50. The analog electronic circuit 110 is connected to the noise source and the LED light source such that the analog electronic circuit 110 converts signals from the noise source into inputs for generating light patterns on the LED light source 50.

15 As would be appreciated by a person skilled in the art, the white noise generator 9 produces random noise at all frequencies, thereby ensuring that no predictable sequence is generated. In alternate embodiments, a microphone 30 may be used in place of the white noise generator 9, for detecting ambient noise or background music. In such embodiments, the noise source comprises ambient noise
20 or music. The system 100 may further comprise an ambient light sensor 35 for detecting ambient darkness such that luminance of the LED 50 is dependent on the ambient darkness. Switches SW1, SW2, SW3 and SW4 for the white noise generator 9, microphone 30, earth connection and ambient light detector 35 respectively may be implemented as a dual in-line package (DIP) switch array 10.

25 The analog electronic circuit 110 comprises a plurality of sub-circuits, including but not limited to a first amplifier 15, a diode envelope detector 20, a second amplifier 25, a voltage comparator 40 and a resistor-capacitor (RC) network 45.

30 With reference to Figures 1 and 2A-2E, the working of the analog electronic circuit 110 is described in detail.

Referring to Figure 1, with the setting of switch SW1 of the DIP switch array
35 10 to "closed" position, while the other switches SW2, SW3 and SW4 are in "open"

position, noise signal from the white noise generator 9 is connected to an input of the first amplifier 15, which has a direct current (DC) bias, for amplifying the signal to a selected voltage range. The amplified white noise at an output 65 of the amplifier 15 is shown in Figure 2A as an example for illustration.

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The amplified white noise signal from the output 65 is fed into the diode envelope detector 20. Components in the diode envelope detector 20 according to an example embodiment are shown in Figure 3, with a resistor 22 having a value of 47 KiloOhms and a capacitor 23 having a value of 2.2 nanoFarad (nF). The capacitor 23 of diode envelope detector 20 discharges at each falling edge of the white noise signal, thereby effectively leveling sharp peaks and removing high frequency noise components such as peak 71. An output 70 of the envelope detector 20 contains the lower frequency components as shown in Figure 2B which is derived from the white noise signal as shown in the Figure 2A. Another effect of the leveling of sharp peaks
10 of diode envelope detector 20 discharges at each falling edge of the white noise signal, thereby effectively leveling sharp peaks and removing high frequency noise components such as peak 71. An output 70 of the envelope detector 20 contains the lower frequency components as shown in Figure 2B which is derived from the white noise signal as shown in the Figure 2A. Another effect of the leveling of sharp peaks
15 may be that the amplitude 74 of the signal at the output of the envelope detector 20 is generally lower than the amplitude 73 of the signal at the input of the envelope detector 20.

A frequency response characteristic of the diode envelope detector 20 is shown in Figure 4 according to an example embodiment in which a sinusoidal signal is used as input V_i , and output V_o is measured. As can be seen from the frequency response curve, components of the white noise signal having frequencies that are more than 50 KiloHertz (KHz) approximately are substantially reduced at the output V_o of the diode envelope detector 20. For components of the white noise signal that
20 are less than about 50 KHz, the amplitude is reduced to a lesser extent as the gain of the envelope detector 20 is still lower than 1.
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In Figure 2B, some remaining high frequency components of the waveform such as portion 72 may still appear at the output 70 of the envelope detector 20, but
30 these components are removed by the second amplifier 25, as will be described in detail below. Thus, substantially all the high frequency components from the white noise signal are eliminated or their amplitude is being reduced to a lower level as shown in Figure 2C, which shows an output signal 75 of the second amplifier 25. Removing high frequency noise components is preferable so that the light patterns
35 generated are at a desired and comfortable frequency range for viewing.

As shown in Figure 2B and Figure 2C, the second amplifier 25, which is an inverting amplifier, both eliminates sections of the signal above a certain voltage value, e.g. 2 Volts (V) in this example embodiment, and inverts the signal such that positive peaks in Figure 2C correspond to negative peaks in Figure 2B. Furthermore, a direct current (DC) voltage level shifting is carried out and a voltage gain of the inverting amplifier 25 is set such that only a few discrete peaks such as peaks 77 are higher than a reference voltage 76, e.g. a 3V reference voltage, as shown in Figure 2C.

The output 75 of the second amplifier 25 is fed into an input of the voltage comparator 40 for comparison with a selected value such as the reference voltage 76. Sections of the waveform that are lower than the reference voltage 76 are automatically eliminated. In the process, only discrete pulses resulting from peaks above 3V are selected for further processing.

An output 80 of the voltage comparator 40 is shown in Figure 2D. As would be appreciated by a person skilled in the art, voltage comparator 80 has a high gain and the output is either at the most positive or most negative with respect to a supply voltage. This effectively converts the discrete pulses into a binary signal such as a square wave signal with two distinct voltage states. In the example embodiment, pulse width T_w 82 varies from approximately 5 microseconds (μs) to 50 μs in random, the time interval T_{pp} 83 between two adjacent pulses varies randomly from approximately 2 milliseconds (ms) to 40ms.

The output 80 of the voltage comparator 40 as shown in Figure 2D is fed into the RC network 45 before driving a base of a transistor 60. The resulting current that passes through the light emitting diode 50 is shown in Figure 2E. A narrow pulse 86 produces a smaller current step 84 of approximately 1mA which transforms into a small flicker in luminance of the light emitting diode 50, while a wider pulse 87 produces a larger current step 88 which transforms into a larger flicker in luminance of the light emitting diode 50. A current slope 89 in between the steps 84 and 88 produces a glow in luminance of the light emitting diode 50. The combined effect is that a flame-like flickering pattern can be observed. The total current variation 85 in the light emitting diode is typically about 5mA.

Similarly, in embodiments in which the noise source comprises ambient noise or music, switch SW2 is in "closed" state and switches SW1, SW3 and SW4 remain in "open" state, thereby connecting the microphone 30 to the analog electronic circuit 110. By the same signal processing as described above with reference to the white noise signal, flickering light patterns corresponding to the ambient noise or music may be generated.

With reference to Figures 5A-5E, an example of an audible sound waveform is shown in Figure 5A at the output 65 of the first amplifier 15. As the frequency is in the audible range (i.e. less than about 50 KHz), the signal waveform as shown in Figure 5B at the output 70 of the diode envelope detector 20 remains substantially the same as the waveform in Figure 5A. The negative peaks of the waveform in Figure 5B are inverted and appear at output 75 of the second amplifier 25 after the amplification as shown in Figure 5C where sections of the signal at output 70 that are above a certain voltage are eliminated by the amplifier 25. A DC voltage level shifting is carried out and a voltage gain of the second amplifier 25 may be selected such that the peaks which correspond to audible sounds are above the reference voltage 76. The voltage comparator 40 compares the waveform 75 with the reference voltage 76 and the output 80 after the voltage comparator 40 is shown in Figure 5D.

For higher frequency audible sound, the pulse interval 125 is smaller. For lower frequency audible sound, the pulse interval 120 is larger. The negative pulse width 110 that is generated from the higher frequency audible sound is smaller than the negative pulse width 115 that is generated from the lower frequency audible sound. For the same frequency audible sound, the louder sound from peak 140 produces a wider negative pulse width 130 than the softer sound from peak 145 that produces a narrower negative pulse width 135. The corresponding waveform of the current through the light emitting diode 50 is shown in Figure 5E. The flickering frequency of the luminance of the LED 50 corresponds to the frequency of the audible sound.

The system 100 as described may be incorporated into a lighting apparatus 600 as shown in Figure 6A. The lighting apparatus 600 may further comprise a cover, such as a semi-transparent lampshade 7, a mounting base 2 and a power supply

input 8. The lampshade 7 may be of different shapes and may be easily replaced from the mounting base 2. As shown in Figures 6B-6D, the microphone 30 and the ambient light sensor 35 (Figure 1) may be conveniently incorporated onto the mounting base 2, and the DIP switch array 10 (Figure 1) may be accessible from a top face of the mounting base 2.

The LED 50 (Figure 1) is preferably mounted to a bottom face of an optical element in the form of a translucent stick 5, which is elongated in an upright direction. The translucent stick 5 together with the LED 50 is mounted on a top surface of the mounting base 2. The shape of the translucent stick 5 may be optimized for manipulating a light emission pattern from the LED 50 to a desired shape such as a flame. For example, the elongated shape may facilitate light propagation along the upright direction such that the emission pattern from the LED 50 appears larger near the top surface of the mounting base 2, and narrower towards the upright direction. Furthermore, due to the semi-transparent lampshade 7, the presence of the translucent stick 5 may not be noticeable, yet the light patterns generated from the lighting apparatus 300 resemble flame flickers.

Figure 7 shows a flowchart 700 illustrating a method for generating light patterns according to an example embodiment. At step 702, a noise source is provided. At step 704, an analog electronic circuit is provided. At step 706, the analog electronic circuit is connected to the noise source and an LED light source, wherein the analog electronic circuit converts a signal from the noise source into an input for generating light patterns on the LED light source.

Although the present invention is described in terms of the specific embodiments, it is to be understood that such disclosure is not to be interpreted as limiting. Various changes and modifications will no doubt become apparent to those skilled in the art after reading the disclosure without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

For example, the user selection of the functions of the electronic lighting base can be in the form of button(s) on the physical base. As another example, the method of generation of the flame-like luminance can be incorporated into a candle or

multiple candles with some modification on the physical lighting base. As a further example, the lampshade can be replaced with a glass or crystal vase that the user has already in possession, and the luminance of the light source that response to the audible sound is illuminated from the base of the vase. As a still further example, the light source can be made of multiple LEDs to enhance the effect of the luminance. A further enhancement would be to include the control circuitry that communicates with a personal computer that allows luminance features to be set or programmed and downloaded by a user. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

CLAIMS

1. A system for generating light patterns, the system comprising:
a noise source;
5 an analog electronic circuit; and
a light emitting diode (LED) light source;

wherein the analog electronic circuit converts a signal from the noise source into an input for generating light patterns on the LED light source.

- 10 2. The system as claimed in claim 1, wherein the analog electronic circuit comprises a first amplifier for amplifying the signal from the noise source to a selected voltage range.

3. The system as claimed in claim 2, wherein the analog electronic circuit
15 further comprises an envelope detector coupled to the first amplifier for removing high frequency components of the signal from the first amplifier.

4. The system as claimed in claim 3, wherein components of the signal
20 that are more than about 50 KHz approximately are removed.

5. The system as claimed in claim 3, wherein the analog electronic circuit
further comprises a second amplifier coupled to the envelope detector for amplifying
and shifting the signal from the envelope detector.

- 25 6. The system as claimed in claim 5, wherein the second amplifier is an inverting amplifier.

7. The system as claimed in claim 5, wherein peaks of an output signal
from the second amplifier are greater than a reference voltage.

- 30 8. The system as claimed in claim 5, wherein the analog electronic circuit further comprises a voltage comparator coupled to the second amplifier for comparing the signal from the second amplifier with a selected value.

9. The system as claimed in claims 7 and 8, wherein the selected value is equal to a value of the reference voltage.

10. The system as claimed in claim 8, wherein an output signal from the
5 voltage comparator comprises a binary signal.

11. The system as claimed in claims 1 and 8, wherein the analog
electronic circuit further comprises a resistor-capacitor (RC) network coupled to the
voltage comparator for controlling a current input to the LED light source.
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12. The system as claimed in claim 1, wherein the noise source
comprises a white noise generator.

13. The system as claimed in claim 1, wherein the noise source
15 comprises ambient noise or music.

14. The system as claimed in any one of the preceding claims, further
comprising an ambient light detector, wherein luminance of the LED light source is
dependent on ambient darkness.
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15. A lighting apparatus comprising the system of any one of the
preceding claims.

16. The lighting apparatus as claimed in claim 15, wherein light patterns
25 generated resemble flame flickers.

17. A method of generating light patterns, the method comprising:
providing a noise source;
providing an analog electronic circuit; and
30 connecting the analog circuit to the noise source and a light emitting diode
(LED) light source;
wherein the analog electronic circuit converts a signal from the noise source into an
input for generating light patterns on the LED light source.

18. The method as claimed in claim 17, wherein the noise source comprises a white noise generator.

19. The method as claimed in claim 17, wherein the noise source
5 comprises background noise or music.