Research on Optical Signal Communication Using RGB Color Organic LED Lighting

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ABSTRACT

Proposed system can realize two signals simultaneous communication by using red and blue light for signals, separated by their difference in wavelength, with RGB color OLED lighting. The maximum frequency of 20 kHz, capable of audio communication, in emission from the OLED was achieved by using a peaking circuit.

1 Introduction

Future lighting will be LED for point light sources represented by light bulbs and Organic LED for surface light sources represented by fluorescent lamps [1][2]. However infrared communication methods have been put to practical use, they are limited to communication within a narrow range [3]. It also requires the addition of a transmitter/receiver dedicated to communicating. One solution to the problem of infrared communication is communication using visible light [3]. It does not cause electronic devices to malfunction. Therefore, there are advantages to use in hospitals and other facilities [4]. In particular, Communication using lighting is expected to be a new means of communication that it has features not found in conventional communications [5].

We propose a lighting system that uses RGB color OLED lighting to achieve multiplex optical communications under wide illumination area, even though while maintaining the lighting function. The proposed system can be used to send double information into the room. And OLED lighting in spite of using fewer structures than LED lighting, can illuminate a room with gentle light that does not glare eyes [6].

2 Proposed System

Figure 1 shows the configuration of proposed lighting system for optical signal communication using RGB color OLED. Each color of OLED lighting driven by DC and AC signals. Only DC emission is used for green, which has a large overlap of emission wavelengths with other colors. An AC signal is superimposed on DC for red and blue, which have small overlap in emission wavelengths. Therefore, modulation is added to red and blue lights, and the two signals are sent out independently for multiplexed communication. The modulated light is separated through color filter and demodulated. The illumination lights are modulated in a signal frequency higher than the critical flicker frequency (CFF), while maintaining ratio between each color component and also the average luminous flux constant [7]. For example, use a signal of 60 Hz or higher, which is the frame frequency of the TV system. At the receiver, a high-speed photo-voltage conversion is performed by a photodiode.

3 OLED Panel

Figure 2 shows an OLED panel. The emission area of the panel is as wide as 123.1mm in length and 123.1mm in width. As shown in Figure 3, the emission area of the panel consists of three RGB colors arranged in long, narrow stripes and divided at an equal pitch of 18.2 μm [8]. The panel is composed of small molecular material [6]. When current is applied to the electrodes of each RGB color on the panel, the three colors can be independently controlled. If the average brightness of each color is driven at a constant level, the emission color is also maintained at a constant level.

4 Measurement of OLED Lighting Characteristics

4.1 Drive Current Characteristics of Luminous Flux

OLED devices are current-controlled light-emitting devices that emit light in proportion to the current flowing through a thin organic film [8]. When applying signal modulation in the proposed system, it is necessary to check the linearity between the drive current Ioled and the light emission.

Figure 4 shows the optical emission characteristics of the OLED panel. It shows that the luminous flux of each color is proportional to the drive current Ioled, indicating a high linearity. Therefore, various modulations can be applied to the luminous flux Φ.

4.2 Spectral Characteristics of Light-emitting and Light-receiving Filters

The spectral radiance of each RGB color was measured. Furthermore, the transmittance characteristics of the optical filters separating the red and blue lights independently. Figure 5 shows the spectral characteristics of each color emission and filter transmittance. Curves are the spectral radiance Le of the OLED panel and the transmittance T of the blue and red filters. From Figure 5, crosstalk of blue signal to red signal is -33dB considered to be able to apply to stereo audio signal. The crosstalk of red signal to blue signal is -46dB considered to be negligible. Therefore, even if two colors, blue and red, are emitted simultaneously, it

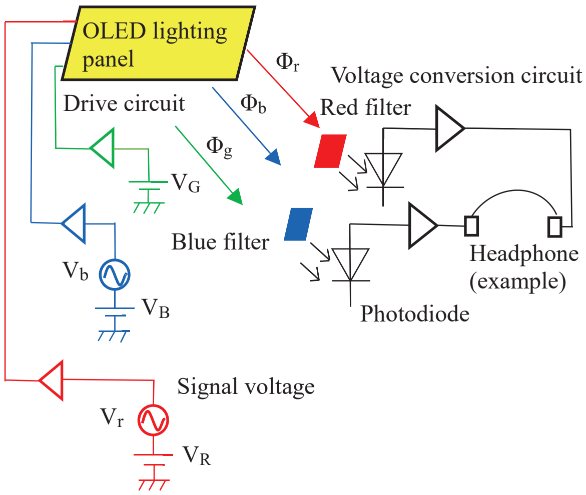

Fig. 1 The proposed lighting system for optical multiple signal communication by rgb color OLED

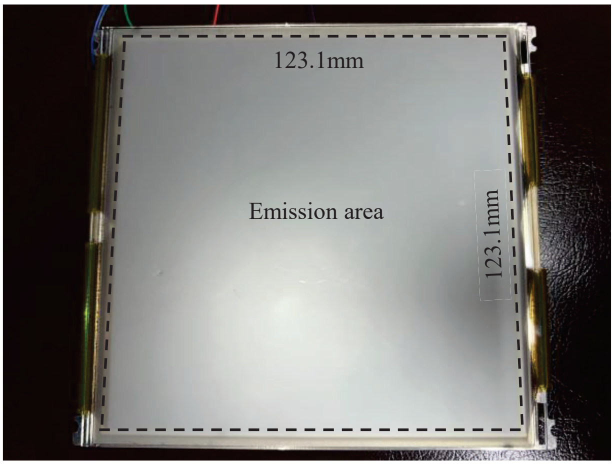

Fig. 2 OLED panel

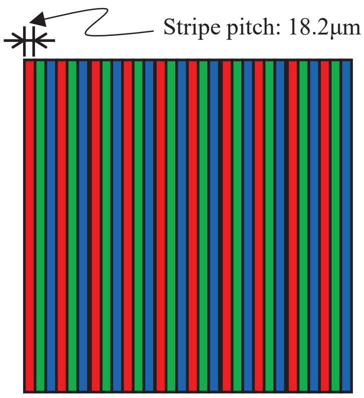

Fig. 3 Light emitting stripe structure of RGB color OLED panel

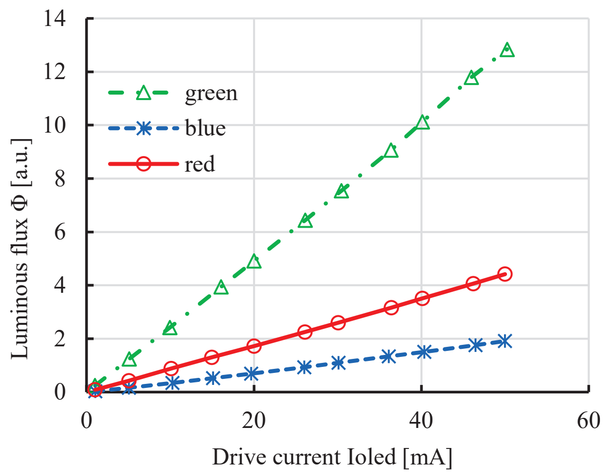

Fig. 4 Optical emission characteristics of OLED panel

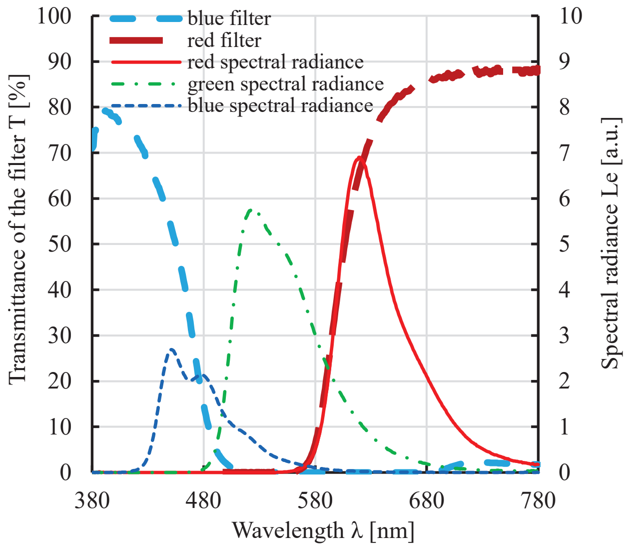

Fig. 5 Color characteristics of emission and filter transmittance

is possible to separate the wavelength components of each color by using the filters. The effect of signal crosstalk can be eliminated by using constant DC emission without modulation for green.

4.3 Frequency Response of Luminescence

We are considering transmitting audio signal through the OLED lighting. Humans perceive audio frequency from 20 Hz to 20 kHz as sound [9]. We have set a target of 20kHz as the maximum transmission frequency required for audio frequency transmission. Therefore, we have measured the frequency characteristics of the present OLED panel. The drive circuit for one color of OLED panel is shown in Figure 6. The OLED lighting is driven by applying DC and AC signals. The drive current Ioled flowing to OLED can be obtained by measuring the voltage drop across the resistor R3 (50Ω). The AC signal

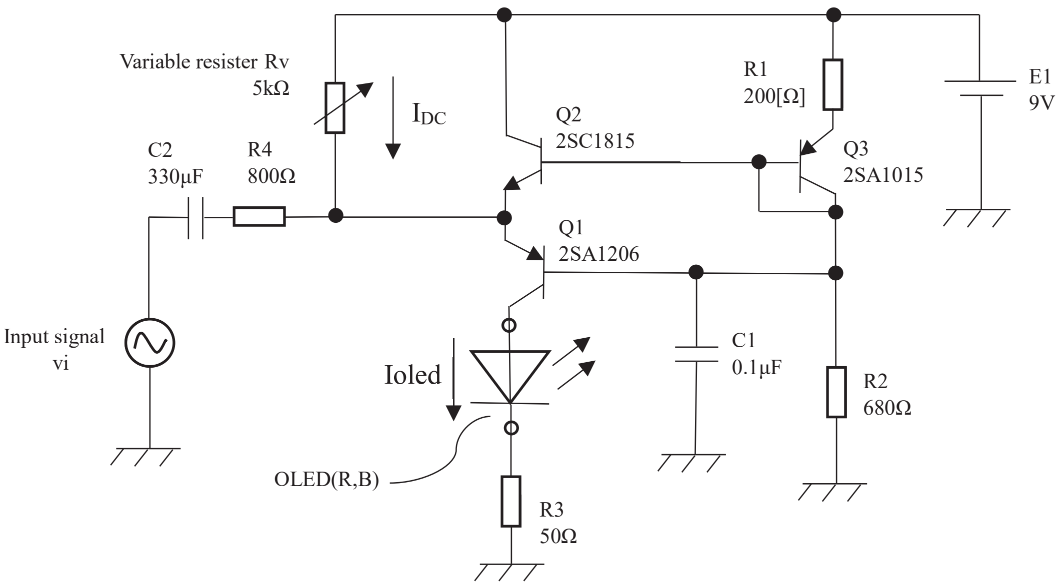

Fig. 6 OLED lighting drive circuit

current flowing to the OLED can be set to the value obtained by vi / R4. The DC drive current is flowing through Rv. Figure 7 shows the measured luminescence frequency response. The cutoff frequency f_{CR} for red emission was 5.51kHz, and f_{CB} for blue emission 6.97kHz. In the current performance, the cutoff frequencies of emission do not exceed 20 kHz necessary for audio signal, which needed to be improved.

5 Improvement of Luminous Frequency Response

Because the cutoff frequencies of red and blue emission were lower than the target of 20 kHz, the frequency peaking was applied to improve the emission frequency characteristics [10]. The peaking equivalent circuit is shown in Figure 8. The series circuit of peaking elements R5 and Cp is connected in parallel to the voltage-current conversion resistor R4 shown in Figure 6. The connected point of N1 and N2 corresponds to the emitter terminal of transistor Q1. The DC bias current IDC flows through the variable resistor Rv.

In general light-emitting devices, light emission decreases inversely proportional to frequency (-20dB/dec) above the emission cutoff frequency. Therefore, at this cutoff frequency, the values of R5 and Cp are designed so that the drive AC current increases proportionally to the frequency (20dB/dec). Thus, the emission attenuation above the cutoff frequency was canceled by the enhancement of the drive current, and the emission frequency characteristics are improved.

Figure 9 shows frequency response of OLED lighting emission after peaking. By applying of the peaking circuit, the red and blue cutoff frequency became 22.9 kHz and 42.1 kHz respectively, meeting the minimum target of 20 kHz.

6 Conclusions

Proposed system can realize two signals simultaneous communication by using red and blue light change for signals, separated by their difference in wavelength, with RGB color OLED lighting.

Table 1 summarizing the measured and analyzed results about characteristics of the OLED lighting panel, shows sufficient adaptability for the proposed system. The drive current characteristics are highly linear for all three colors and are adaptable to the proposed system. The spectral characteristics of each color emission and filter transmittance can separate red and blue light signals. The maximum frequency of 20 kHz, capable of audio communication, in emission from the OLED was achieved by using a peaking circuit.

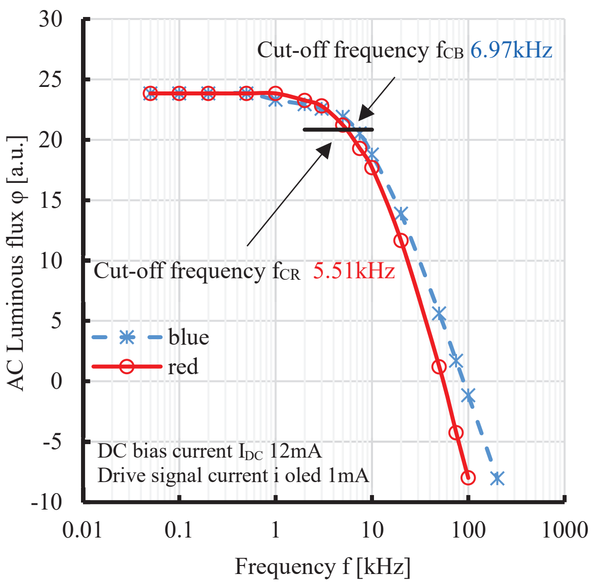

Fig. 7 Frequency characteristics of OLED lighting emission

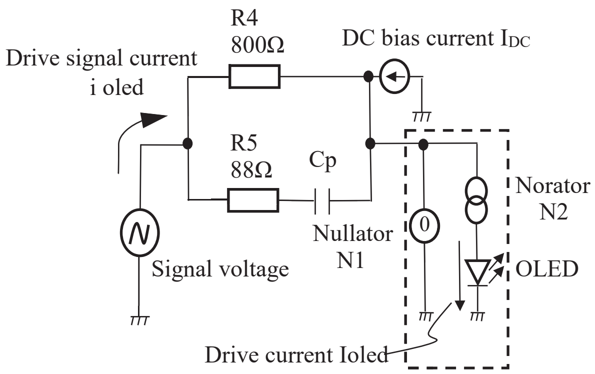

Fig. 8 Peaking equivalent circuit

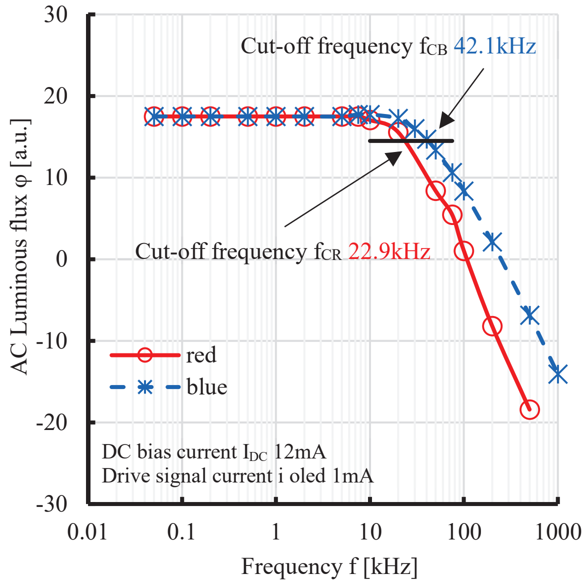

Fig. 9 Frequency response of OLED lighting emission after peaking

Table. 1 Adaptability of evaluated OLED panel to the proposed system

Characteristic		Measured and analyzed results	Judgment
Driving current		High linearity with luminous flux	○
Spectral radiance		Separatable for Red and blue	○
Transmittance of the filters		Separatable for Red and Blue	○
Cut-off frequency in emssion	Red	22kHz (> 20kHz)	○
	Blue	32kHz (> 20kHz)	○

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