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INFORMATION BROADCASTING SYSTEM BASED ON VISIBLE LIGHT SIGNBOARD

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ABSTRACT
We present the feasibility of visible light information broadcasting system based on message signboard. This system can provide the bit error rates (BERs) lower than 10^{-6} at 4-Mbps and 10-Mbps data rate. Using four LED array modules, 4-Mbps visible light signals could be transmitted over 4.2 m. In case of 10-Mbps data rate, the maximum transmission distance was 3.6 m.

KEY WORDS
visible light communication, information broadcasting, LED, signboard

1. Introduction

Recently, the usage of light-emitting diodes (LEDs) for illumination have been increased since they have the long life expectancy, high tolerance to humidity, low power consumption, minimal heat generation over incandescent lights [1], [3]. LEDs are used in display boards, signal devices, and many other means of illumination. Furthermore, we can modulate the emitting lights by LEDs with digital signals since they can switch fast with the additional electronics as semiconductor devices [1-3]. Therefore, in addition to their normal function as indication and illumination devices, LEDs can be used as communication devices for transmitting and broadcasting digital information. The visible LED communication systems can be applied to commercial/public signboard and LED traffic lights [4], [5]. In this paper, we presented the feasibility of optical wireless communication based on the visible LEDs. We demonstrated the 4-Mbps and 10-Mbps information broadcasting system using a message signboard.

2. Experiment

Fig. 1 shows the experimental setup for information broadcasting system based on visible signboard. The message signboard for transmitting digital information consists of four LED array modules. Each LED module is composed of 512 bulk LEDs (16 x 16 red and green LEDs) and 32 drivers. Eight red LEDs were connected in parallel and modulated by a driver. The red LEDs were synchronized one another and directly modulated with $2^7 - 1$ pseudorandom binary non-return-to-zero (NRZ) sequences at 4-Mbps or 10-Mbps data rates. Fig. 2(a) shows the logo of Samsung Electronics displayed by 4 LED modules. The PIN photo-diode was used to detect the digital signal. To concentrate more visible lights, a convex lens in front of photo-diode (PD) might be utilized. In free optical communication systems, it is hard to measure the power of optical light launched at PD directly. In this experiment, the optical power meter with optical sensor was used as shown in Fig. 1. The errors of data detected by receiver were counted by bit error detector. Fig. 2(b) shows the receiver used in this experiment.

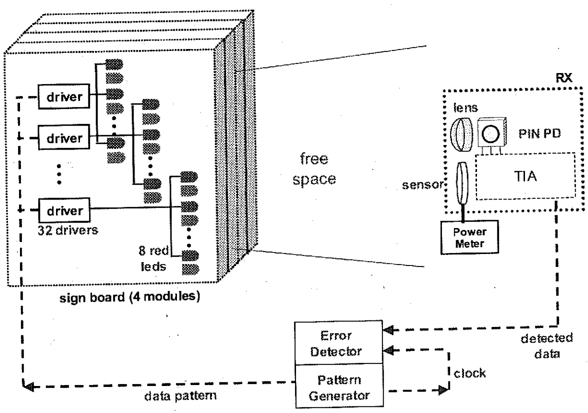
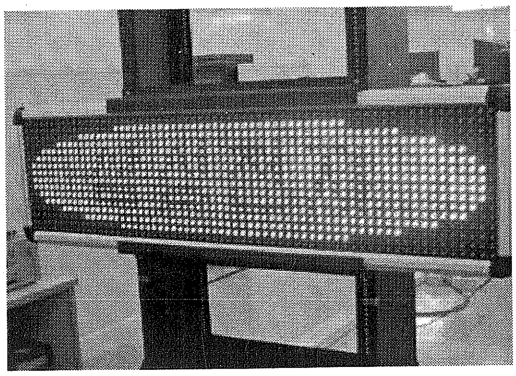
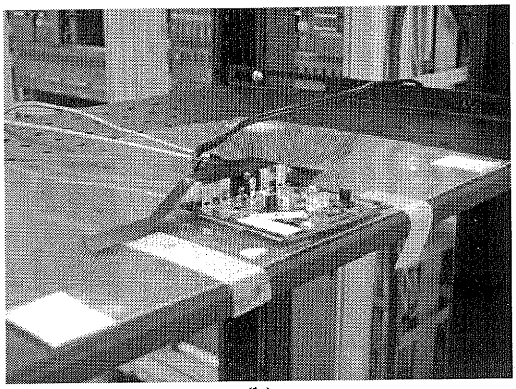


Fig. 1. Experimental setup



(a)



(b)

Fig. 2. TRX of visible light information broadcasting system. (a) signboard (TX) and (b) RX

3. Experimental results

Fig. 3 shows the optical power measured in front of PD as a function of the transmission distance and the number of LED modules. '1 module' of Fig. 3 indicates that all red LEDs of one module turned on. 'Samsung' indicates the logo shown in Fig. 2(a). For the short distance, the number of LED modules has a little effect on received power. In case of 0.6-m distance, the received power difference between the plural LED modules was within 0.4 dBm. However, the received power difference of between '2 modules' and '4 modules' increased to 1.5 dBm at the distance of 1.6 m.

To investigate the performance of message signboard, we measured the bit error rate (BER) curves varying the transmission distance, data rate, and the number of modules. The target BER was set to 10^{-6}. Fig. 4(a) shows the measured BER curves as a function of the transmission distance and the number of LED modules for 4-Mbps data rate. As the number of LED modules with turn-on state increased, the BER performance improved and the transmission distance increased. In case of '4 modules', the maximum transmission distance was 1.25 m. Generally, the BER of 10^{-6} was satisfied for the received power above –8.5 dBm. For the short distance, the BER of '2 modules' was better than that of 'Samsung' due to the high concentration of LED array. However, as the distance was above 1.0 m, 'Samsung' exceeded '2 modules' in BER. That is because the LED coverage of 'Samsung' is larger than that of '2 modules'. Hence, the performance of visible light information broadcasting depends on the concentration and coverage of LED array. To improve the system BER performance, we utilized a concentration lens in front of PD of receiver. The concentration lens is a convex lens and has the 6-mm diameter. Fig. 4(b) shows the measured BER values with the concentration lens at 4-Mbps data rate. In case of '3 modules', the transmission distance was increased by 2.6 m. For the plural LED modules, the transmission distance above 2.0 m was improved by using the concentration lens.

For 10-Mbps data rate, it is hard to satisfy the required BER without the concentration lens. Fig. 5 shows the measured BER values with the concentration lens at 10-Mbps data rate. The maximum transmission distance was 3.6 m for '4 modules'. In case of 'Samsung', the BER less than 10^{-6} could be satisfied within 2.7-m transmission distance. We believe that the transmission distance and coverage can be improved as all of red, green, and blue (RGB) LEDs were modulated.

4. Conclusion

We present the feasibility of visible light information broadcasting system based on message signboard. This system can provide BERs lower than 10^{-6} at 4-Mbps and 10-Mbps data rate. Using four LED array modules, 4-Mbps visible light signals could be transmitted over 4.2 m. In case of 10-Mbps data rate, the maximum transmission distance was 3.6 m. The transmission distance and coverage might be improved as all of RGB LEDs could be modulated.

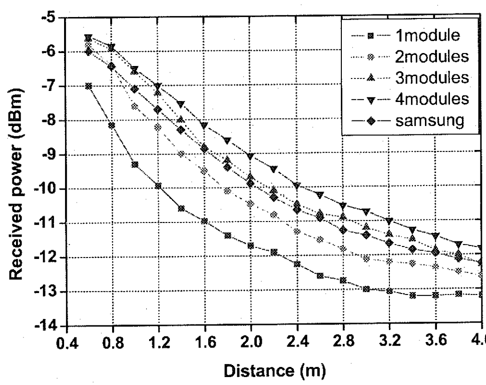
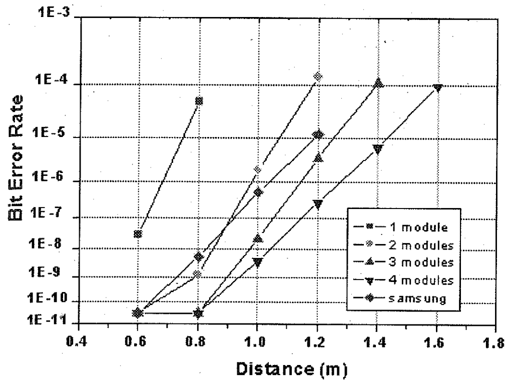
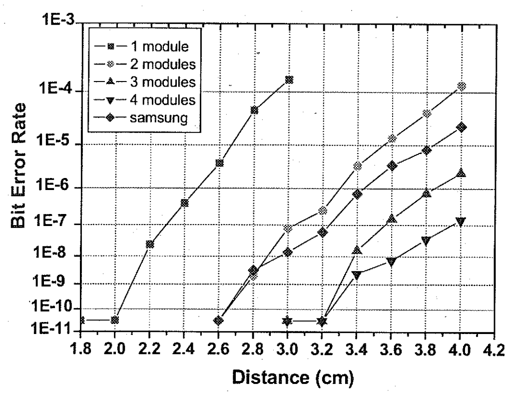


Fig. 3. Measured received power as a function of distance and number of LED modules



(a)



(b)

Fig. 4. Measured BER as a function of distance and number of LED modules at 4-Mbps. (a) without concentration lens and (b) with concentration lens

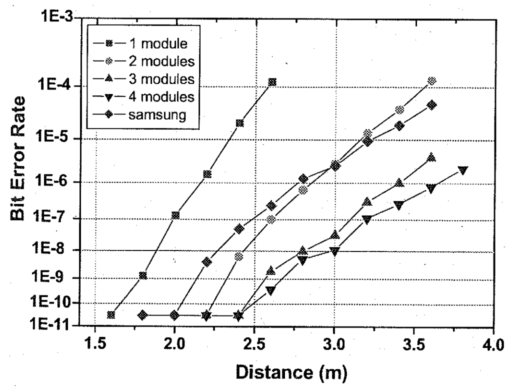


Fig. 5. Measured BER as a function of distance and number of LED modules at 10-Mbps

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