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Gigabits Transmission over a RGB LED by using WDM

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***Abstract*—Light-emitting diodes (LEDs) plays vital part in various applications in our daily lives. RGB-LED's are one of the most popular light source which can be used for transmission of gigabit information. Visible light communication is attracting growing interest for wireless communications since it is low-cost and easily maintained by using high-speed switchable LEDs. In this paper, we simulate for bi-directional indoor communication system based on optisystem. Spectrally efficient modulation formats mech-zehnder modulation, arrayed waveguide grating, wave division multiplexing are adopted to compensate the severe frequency response of indoor channel. Red-green-blue LEDs are used to carry different signals. For downlink, the low frequencies of each color are used while for uplink, the high frequencies are used. The overall data rate is downlink 1-Gb/s, uplink500-Mb/s and we analyse spectrum for power (dBm) vs frequency.**

keywords—Light-emitting diode (LED), modulationbandwidth, nonlinearity, visible light communication (VLC).

I. INTRODUCTION

Thelighting industry increasingly employs white-led devices for illumination and signalling applications. It is thought that such solid-state lighting will eventually replace existing conventional lighting sources due to their reliability and predicted high efficiency. Such sources can also be modulated to provide simultaneous illumination and communication visible light communications (vlc) was conceived in japan [4], [5], and there is increasing interest in Europe, including work in a European commission framework7 project omega [3]-[5]. Standardization work is also underway within the ieee [6].

High-luminance white light emitting diodes(LEDs) have been made a big improvement intheir performance such as high bright output, high power efficiency, and a long lifetime.Therefore, their application area will be expected to a large massive application of general lighting.And now, they replace incandescent or fluorescent lights in offices,homes, cars, and traffic lights. There are many approaches to realize highspeed visible light communication (VLC) system.In the case of on-off-keying (OOK)-nonreturn-tozero(NRZ) based transmission, a 125 Mbit/s transmission experiment was demonstrated in VLC link with a phosphorescent white LED and a low-cost PIN photo diode (PD).

However, this experiment required filtering the low-speed phosphorescent component to increase the bandwidth of the VLC system. A 477 Mbit/s OOK-NRZ based transmission experiments was also reported using a single red LED of a RGBtype white LED with a pre-emphasis circuit [2]. LED-to-LED VLC with the aim of achieving rates of the order of ~100 Mb/s, using a commercially available LED with larger (emitting/detecting) area. After characterisation of the device, a very simple On-Off-Keying (OOK) based system is tested. Then, its present a bi-directional LED-to-LED link employing orthogonal-frequency-division-multiplexing(OFDM) [3].

Bit sequence generator is an algorithm for generating a sequence of numbers whose properties approximate the properties of sequences of random numbers. Optical pulse generators are the optical equivalent to electrical pulse generators with rep rate, delay, width and amplitude control. The output in this case is light typically from a LED or laser diode.Arrayed waveguide grating are based on a fundamental principle of optics that light wave of different wavelengths interfere linearly with each other. it means that, if each channel in an optical network makes use of light of a slightly different wavelength, then the light from a large number of these channels can be carried by a single optical fiber with negligible crosstalk between the channels. The AWGs are used to multiplex channels of several wavelengths onto a single optical fiber at the transmission end and are also used as demultiplexers to retrieve individual channels of different wavelengths at the receiving end of an optical communication network.

In this paper, simulate a significant increase in data rate for a WDM VLC link based on an integrated 3-channel LED driver. For the first time the Gigabit range has been entered by a single LED based VLC wireless link with an aggregate rate of 1 Gbit/s. The illuminance level at the receiver site was set to be in the range recommended for a working environment.

II. CONFIGURATION OF PROPOSEDSYSTEM

The block diagram describing the full-duplex AWG-WDM transceiver structure is shown in Fig. 1. RGB LEDs are used as the VLC transmitters (TXs) for both uplink and downlink, which generate a luminous flux of about 106lm (red: 30.6lm, green: 67.2 and blue: 8.2lm) at 350mA bias currents with 110° Lambertian emission. It consists LEDs are radiating in 625nm (red), 530nm (green), 455nm (blue) color. Low costPIN PDs are adopted for the receivers (RXs). At thetransmitters, the mech-zehnder modulation signals which consist of 3 subcarriers are generated by an arrayed waveguide grating (AWG).

channel of each color LED. The transmission data rate at downlink of red, green and blue colors are 375Mb/s.

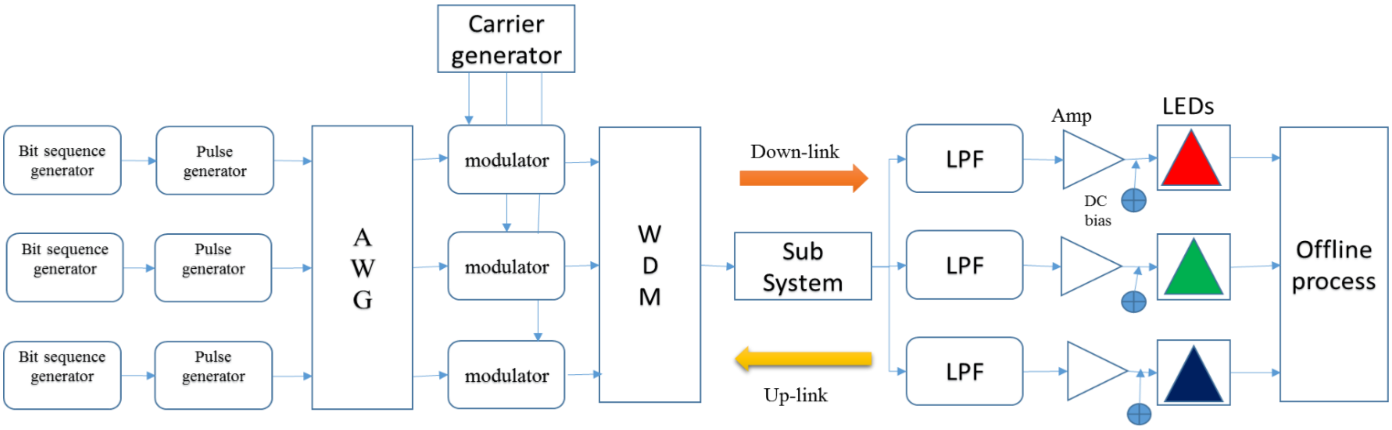

Fig.No.1 diagram of bidirectional transmission system

For the downlink, red, green, and blue wavelengths are all used to carry useful information, and each one includes three carrier generator, three arrayed waveguide grating AWG signals with a bandwidth of 25MHz are modulatedindividually with different frequency at18.75MHz (sub1), 43.75MHz (sub2), and56.25 MHz (sub3).For the uplink, only one sub-channel ismodulated at individual color, but occupied at a higher frequency at 81.25MHz (sub4) this time in order to realize a seamless frequency allocation and avoid overlapping at frequency domain.

Thus the WDM scheme can successfully simultaneously support 9-user downlink and 3-user uplink transmission. The data rates and numbers of uplink and downlink can be dynamically reconfigured by changing the centre frequency and modulation orders of carrier, and adjusting the bandwidths of baseband arrayed waveguide grating AWG signals.After modulate to the optical source,

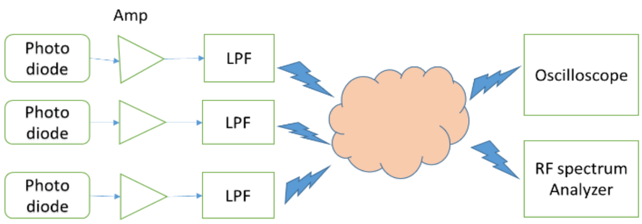

Fig.No.2 Offline Process

the signals are passing through LPF and EA. The electrical amplifier is operated below Saturation to eliminate the nonlinearity. The transmission bands of red, blue, and green filter are 605nm-730nm, 390nm-480nm, and 500nm-580nm, respectively. Then, the detected electrical signals are shown in RF spectrum analyser and oscilloscope visualizer. So the overall data rate of downlink is 1-Gb/s and uplink is 500-Mb/s. The measured electrical spectra of three LEDs are shown in Fig. 2. Meanwhile, the amplitude vs. time of LED are shown in Fig. 3.1. Fig. 3.2 represent the three downlink of red, green and blue color LED chips, respectively. And Fig. 3.1 fig 3.2 shows the uplink sub-

III. SIMULATION RESULTS AND DISCUSSION

The system is a pear-to-pear one in thissimulate, and the PD should be placedon or near the focus plane of lens. The opticalsignals are generated by optical sech pulse generator with the maximum sampling rates of 24 GS/s and bandwidths of 6 GHz. The electrical signals from the RX are recorded by OSC with the maximum bandwidth of 6GHz and the maximum sampling rate of 20GSa/s. The luminous flux of LED chips at 350mA bias currents is 30.6lm (red), 67.2 (green) and 8.2lm (blue).The distance between the TX and RX in the different side is 70cm, and the distance in the same side can be neglected. As for the

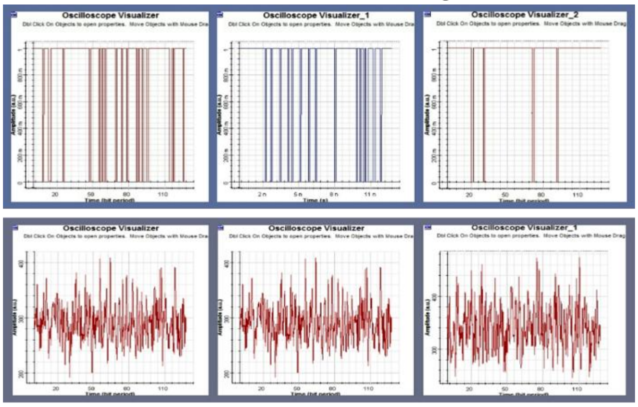

Fig.no 3.1 downlink and uplink output (red, green, blue)

limited experiment condition, the three different optical sech pulse signals of each link are shared by theone AWG output via power splitter.

According to the channel response, the modulation formats of three different frequencies are used inmech-zehndermodulation format. So the overall data rate of downlink is 1-Gb/s and uplink is 500-Mb/s. The measured electrical spectra of red LED are shown in Fig. 2.2. It can be easily seen that the spectra in each sub-channel are much more flatten by using pre-equalization. A coarse power allocation is made between different sub-channels, to satisfy the demand of different modulation orders. Meanwhile, the performance of amplitude vs. time (bitperiod)uplink and downlink output signals are shown in Fig. 3.1.Represent the three sub channels in downlink of red, green and blue color LED chips, respectively. The transmission data rate at downlink of red, green and blue colors are 375Mb/s, 375Mb/s, and 400Mb/s. Therefore, the overall transmission data rate of downlink is1Gb/s. and the data rate of uplink at each color is167Mb/s, hence to obtain the overall uplink data rate is 500Mb/s.From the simulation

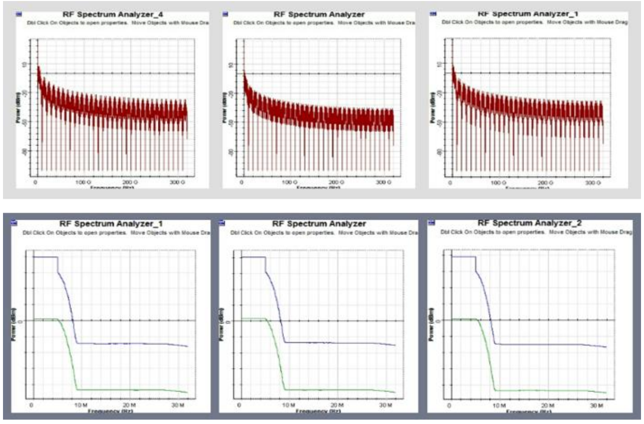

Fig.no.3.2 spectrum of downlink and uplink(red,green,blue)

results and discussions, we can validate the feasibility of this two-stage bi-directional transmission scheme.

IV. CONCLUSIONS

In this paper, we have proposed to simulate a novel bidirectional transmission system, based on commercial RGB-LEDs and low-cost APDs. A two-stage color/frequency allocation scheme has been proposed. We have achieved 1-Gb/s downlink and 500-Mb/s uplink transmission data rates enabled by higher order modulation, mech-zehnder modulation, arrayed waveguide grating, wave division multiplexing has great potential in bi-directional transmission and multiple access in VLC system. By using these technique simulation results show that our proposedsystem is suitable for a simple, low-cost, andhigh-speed VLC system.

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