International Journal of Research (IJR)

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 9 Issue 05
May 2022

Comparison of the Light Source Between the Wide and Narrow Bands of the Experimental Results of Free Optical Space

Mohamed Mansour Shukra[1],Alsanossi M. Aboghrara[2],Ahmed Imsaeri Omar Imsaeri[3]

Moh.Shukra@Fezzanu.Edu.Ly,als. abdulhafid@sebhau.edu.ly, Ahm.Imsaeri@Fezzanu.Edu.Ly
Fezzan University, Faculty of Education, Physics Department
Sebha University, Renwable Energy , Engineering Department

ABSTRACT

In this paper, the experimental results of free-space optical communication between broadband and narrowband light source are compared. Verifying the feasibility of broad-spectrum FSO communication link through atmospheric turbulence can be achieved by reducing the inter-symbol interference caused by excessive noise with addition of adaptive equalizer.a free-space optical (FSO) communication system with supercontinuum source generated by dispersion shift fiber (DSF) from pulsed light modulated by optical switches is designed and constructed. In addition,
The experimental results
show that the super continuum can be used as the optical signal carrier, and the signal can be wirelessly transmitted under the space atmospheric channel condition.

Keywords: Free-space optical (FSO) communication, Supercontinuum source, Partial coherence beam (PCB)

1. INTRODUCTION

Free-space optical (FSO) communication is for delivering low-cost, license-free and high-bandwidth access solution as a flexible and effective transmitting method which can greatly ease the growing demand for radio frequency spectrum resources. However, the FSO technology is highly susceptible to the effects of atmosphere turbulence in that the decreasing transmitting performance is resulted by atmospheric loss, turbulence-introduced channel fading, and pointing errors (PEs) [1-3]. There are feasible approaches to improve the signal quality by increasing transmitting beam power and aperture of a receiving telescope and the use of several spaced sub-apertures as a receiver.

According to a large number of studies indicates that the decrease in the degree of coherence of a transmitting beam resulting in the improvement of quality of FSO communication link, reducing bit error rate (BER) and PEs [1-3]. It is known that the supercontinuum, as early as 1970 found in solid and gas nonlinear media, is generating by the optical pulse through a series of nonlinear effects leading to spectral broadening which can be used as a suitable carrier light source for FSO communication due to its partly coherence to further improve the performance quality [1-3].

The aim of this work is to verify the feasibility of high-precisely FSO communication link through atmospheric

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 9 Issue 05
May 2022

turbulence based on broad-spectrum communication link of the supercontinuum.

In this paper, we utilize optical switch to bring about pulse square-signals by pumping several kinds of fibers to realize the generation of supercontinuum and modulating the intensity of its time domain pulse signals, then demodulating by low-pass filter. The feasibility of broad-spectrum FSO communication link through atmospheric turbulence is further analyzed according to the experimental results**.**

2. PRINCIPLE

Scheme diagram of FSO communication link based on a novel method to generate supercontinuum by optical switches is shown as Fig.1. The pulse signal with stable mode is generated by changing the square wave duty cycle of a 1GHz radio frequency from arbitrary waveform generator AWG (KEYSIGHT M9502a) to modulate the intensity of 1550nm continuous light. The power of the pulsed light can be adjusted by changing the duty cycle.

The generated pulse signal can be observed in real time by connecting a 90:10 coupler and 10% introduced to the oscilloscope (OSC, KEYSIGHT DSO-X 93204a), while the 90% optical signal through the erbium-doped fiber amplifier amplification (EDFA) and into the 3000 meter dispersion shift fiber (DSF). Then a 99: 1 coupler is used to introduce 1% into the optical spectrum analyzer OSA (YOKOGAWA AQ6375) to monitor its supercontinuum. Meanwhile by adjusting the duty cycle, we can search an optimal value in the frequency domain and time domain at the same time and then modulate the amplitude of the broad-spectrum pulse signal, collimating it into the space channel on the atmosphere transmission. The optical signal received by the photodetector (PD) is passed through a low-pass filter to observe the eye of the signal and compare it to the original signal

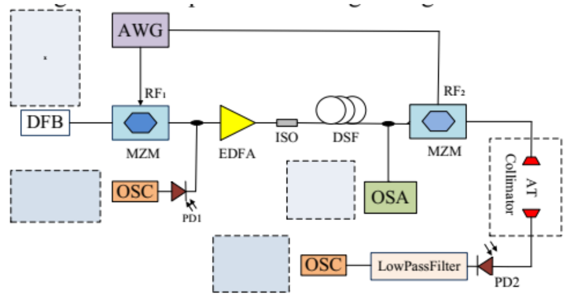

Fig.1 Schematic diagram of the free-space optical communication link based on supercontiuum. DFB: distribution feedback laser. MZM: mach-zehnder modulator. EFDA: Erbium-doped fiber amplifier. ISO: isolator. DSF: dispersion shifted fiber. AT: atmospheric turbulence channel. PD: photodetector. AWG: arbitrary waveform generator. OSA: optical spectrum analyzer. OSC: oscilloscope. RF: radio frequency signal

2.1 generation of supercontinuum

SC generation in nonlinear single-mode optical fiber can be simulated in a reliable manner by solving the generalized nonlinear Schrödinger equation (GNLSE), which contains contributions from the linear dispersion of the fiber and various nonlinear processes like the self-phase modulation (SPM), cross phase modulation (XPM) and four wave mixing (FWM) effect, stimulated Raman scattering (SRS) and stimulated

Brilliant scattering (SBS) and other nonlinear effects that lead to spectral broadening.

A propagation equation describing the evolution of the optical pulse envelope in an optical fiber can be derived from analytic simplification of Maxwell's equations. control and monitoring of each sub-module are complex.

$$\nabla^2 \mathrm{E} - \frac{1}{\mathrm{c}^2}\frac{\partial^2 \mathrm{E}}{\partial t^2} = \mu_0 \frac{\partial^2 \mathrm{P}_L}{\partial t^2} + \mu_0 \frac{\partial^2 \mathrm{P}_{NL}}{\partial t^2} \qquad (1)$$

3. EXPERIMENTAL RESULTS

Continuous light generated from the laser modulated by the Mach-Zehnder modulator to produce a stable mode of the pulse beam, optical power amplified by EDFA, after passing through a 3000 meters long DSF, the generation of supercontinuum can be observed by the optical spectral analyzer(OSA),as shown in Fig. 2.

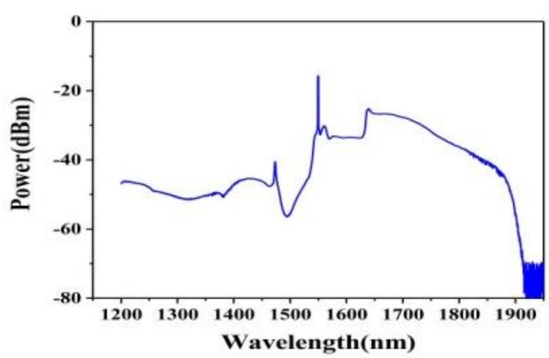

Fig.2 700nm~ width broaden spectrum after pulse light passing through a 3000m-long DSF. After the intensity modulation of the broad spectrum signal, the pulse sequence carrying the pseudo-random signal is shown in Fig.3a, and Fig.3b shows the demodulation signal after the 1GHz bandwidth low-pass filter.

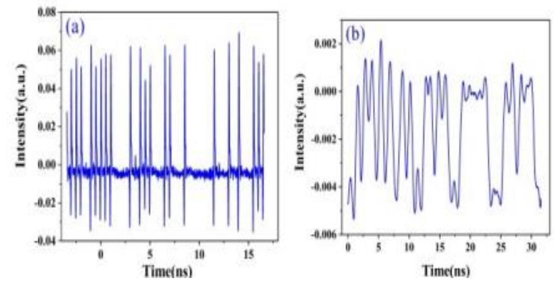

Fig.3 time-domain diagram of the pulse amplitude modulation carrying pseudo-random code signal. (a) signal before low pass filter. (b) signal after low pass filter.

The received eye diagram of back-to-back signal by demodulation from supercontinuum is shown as Fig.4. It is obvious that serious inter-symbol interference resulting in distortion of the signal. The possible reason is due to the super continuous spectrum of the frequency width far beyond the intensity modulator modulation range, the introduction of excessive noise causing a series of serious inter-symbol interference which leading to signal distortion.

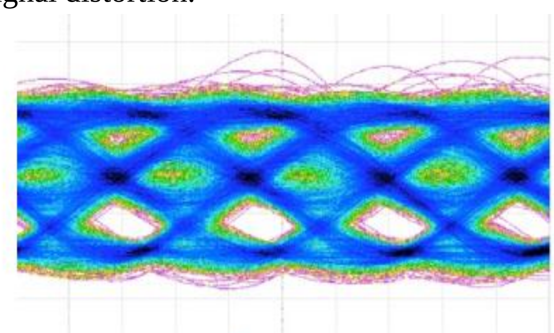

Fig.4 BTB eye diagram signal of directly demodulation from supercontinuum. Figure 5 is the back-to-back PAM demodulation eye diagram signal. An eye diagram of the narrowband light source PAM signal demodulated by intensity modulation of the pulsed beam

without entering the nonlinear optical fiber. It can be clearly observed that inter-symbol interference is reduced by the decreasing introduction of noise due to the over-width of the supercontinuum.

The resulting signal does not differ from the expected signal, while the receiver does not have adjacent pulse interference due to channel reason.

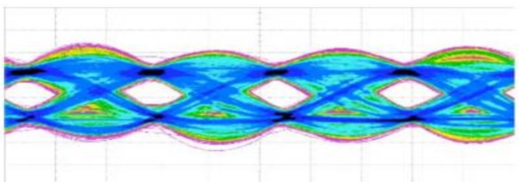

Fig.5 eye diagram signal of BTB PAM demodulation

Building up a 2Gbit/s rate of back-to-back broad-spectrum communication link in this paper, the next experiment plans to communicate through the atmospheric turbulence channel, pre-generated inter-symbol crosstalk can be added by adding adaptive equalizer to improve.

4. CONCLUTION

In this paper, we utilize optical switch to bring about pulse square-signals by pumping several kinds of fibers to realize the generation of supercontiuum and modulating the intensity of its time domain pulse signals, then demodulating by low-pass filter. Verifying the feasibility of broad-spectrum FSO communication link through atmospheric turbulence can be achieved by reducing the inter-symbol interference caused by excessive noise with addition of adaptive equalizer.

5. REFERENCES

[1] I. E. Lee, Z. Ghassemlooy, W. P. Ng and M. A. Khalighi, "Reducing pointing errors in free-space optical communication links over turbulences with a partially coherent Gaussian beam," 2016 IEEE International Conference on Communications Workshops (ICC), Kuala Lumpur, 2016, pp. 163-168.

[2] R. Yang,Q. Liu and Z. Wu, "Effects of atmospheric turbulence scintillation on the error performance of partially coherent laser communication," 2009 3rd European Conference on Antennas and Propagation, Berlin, 2009, pp. 1782-1785.

[3] A. K. Rahman, S. A. Aljunid, M. S. Anuar and H. A. Fadhil, "Improve the bit error rate performance of free space optic due to atmospheric turbulence using new dual diffuser modulation," 2014 IEEE 5th International Conference on Photonics (ICP), Kuala Lumpur, 2014, pp. 96-98.