iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** V **Month of publication:** May 2020

DOI: http://doi.org/10.22214/ijraset.2020.5399

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

Different Comparison Methods Modulation for WOM Communication System

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Abstract: In the paper, we present and demonstrate experimentally a 10Gbit/s on-off keying (OOK) bidirectional wavelength-division-multiplexing (WDM) free space optical (FSO) communication architecture integrated in fiber network together with 5 m free space transmission length and 25 km fiber link, respectively. To achieve bidirectional FSO link, the all WDM wavelengths can be used simultaneously to serve as the downstream and upstream traffics in the proposed FSO- WDM system. Here, four pairs of line terminations (LTs) and optical wireless units (OWUs) and integrated arbitrarily in fiber access network for confidential and bidirectional FSO connection based on the requirement of practical environment. In the measurement, the relationship of FSO signal performance and detected tolerance are also discussed and analyzed. Moreover, the WDM-FSO transmission can also avoid the Rayleigh backscattering (RB) beat noise in fiber connection.

I. INTRODUCTION

The free space optical (FSO) communication technologies could be utilized to offer the advantage of high speed, broad capacity and cost effectiveness, due to the bandwidth demands of multi-service and diverse applications of next generation communications. The FSO transmission system, integrated in broadband fiber networks and wireless transmissions, has the high compatibility without signal interference for broadband data access. FSO system would also be the gorgeous technology for the metropolitan network extension. FSO system could be comprehensive platform to deliver the optical wireless connection everywhere for data traffic. The FSO traffic could be influenced by the atmospheric turbulence and weather status.

To meet the broadband requirement for last mile access, the FSO and millimeter (mm)-wave communication can be combined in the passive optical network (ON) for wireless data. The fiber network connection may be not suitable to build up due to the limited geographical environment. The MMW signal could only provide a shorter propagation length due to the atmospheric absorption. The LED –based VLC systems are applied in the indoor access application due to the limited bandwidth. The LD-based VLC are most utilized in the outdoor and the underwater communication to maintain larger wireless data traffic. In this paper, we propose and demonstrate experimentally a bidirectional wavelength-division-multiplexing (WDM)-FSO system with 10 G bit/s OOK wireless data, which is integrated in fiber access network, after 25km fiber link and 5 m free space transmission length. Here, five WDM wavelengths are employed simultaneously for four pairs of line terminations (LTs) and optical wireless units (OWUs) based on our proposed WDM-FSO network architecture for bidirectional FSO traffic with the different downstream and upstream wavelengths. In the measurement, the FSO signals can transmit through a 25 km SMF first and then emit through a 5 m free space transmission length; and emit through a 5 m free space transmission length first and then transmit through a 25 km SMF for data detection, RB beat noise can also avoided.

II. LITERATURE SURVEY

A. Performance Analysis of OOK modulation scheme with spatial diversity in atmospheric turbulence-At very strong turbulance level, a significant improvement in diversity gain is seen when the number of receivers are large though at the cost of increase in system complexity.
B. C-RAN with Hybrid RF/FSO Fronthaul links:Joint Optimization of RF Time Allocation and Fronthaul Compression-our simulation results reveal that a considerable gain in terms of sum rate can be achieved by the proposed protocol in comparision with benchmark schemes from the literature,especially when the FSO links experience unfavorable atmospheric conditions.
C. Extended Measurement Tests of dual polarization rado over fiber and radio over FSO F ronthaul in LTE C-RAN architecture-In addition, the combination of 10km fiber and FSO link is tested under turbulance FSO channel condition showing EVM values below the threshold of 9% even under a strong turbulance regime.
D. Using single side-band modulation for coloress OFDM- WDM access network to alleviate Rayleigh backscattering effects-the RB circumvention can be centralized in the CO. Moreover, the signal performances of downstream and \upstream are also studied and discussed in these measurement.

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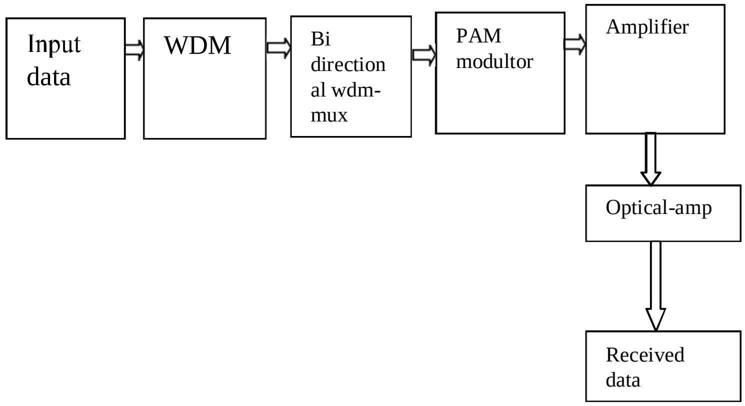


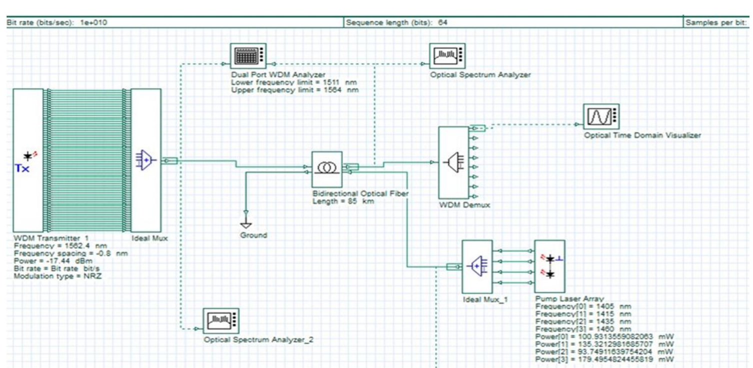
In this paper, we propose and demonstrate experimentally a bidirectional wavelength-division-multiplexing (WDM)-FSO system with 10 Gbit/s OOK wireless data, which is integrated in fiber access network, after 25 km fiber link and 5 m free space transmission length. Here, five WDM wavelengths are employed simultaneously for four pairs of line terminations (LTs) and optical wireless units (OWUs) based on our proposed WDM-FSO network architecture for bidirectional FSO traffic with the different downstream and upstream wavelengths. In the measurement, the FSO signals can transmit through a 25 km SMF first and then emit through a 5 m free space transmission length; and emit through a 5 m free space transmission length first and then transmit through a 25 km SMF for data detection, respectively for demonstration. The whole power sensitivities of < −24.2 dBm of five WDM FSO signals can be completed. Hence, the proposed WDM FSO transmission not only can be exploited for dedicated connection, but the RB beat noise can be also avoided. In addition, the available tolerance of ±1.14 cm displacement (±0.1305◦ rotation angle) is allowed in the Rx side for FSO traffic to satisfy the forward error correction (FEC) target under a 5 m long wireless transmission length.

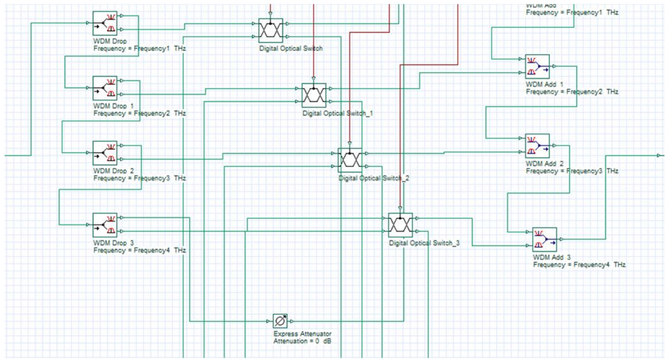
III. BLOCK DIAGRAM EXPLANATION

Input data of electrical signal is converted into optical signal, Wavelength Division Multiplexing(WDM) the wavelength will occurs from the PAM(Pulse Amplitude Modulator)using optical amplifier receiving the data. Amplifier-It is a electronic device that increases the voltage,current or power of signal.Amplifiers are used in wireless communiation and broadcasting,and in audio equipments of all kinds. WDM-Wavelength Division Multiplexing data streams over optical carriershaving different wavelengths called channels and sent as a single signal.PAM-Pulse Amplitude Modulation is a form of signal modulation where themessage information is encoded in the amplitude of series of signal pulses. Optical Amplifier-It is a device that amplifies an optical signal directly without the need to first convert it to an electrical signal.

IV. SOFTWARE MODULE WITH EXPLANATION

OPTI SYSTEM 16-Opti system is an optical communication system simulation package for the design,testing,and optimization of virtually and type of optical link inthe physical layer of a broad spectrum of optical networks,from analogvideo broadcasting systems to intercontinental backbones.





Owing to some geographical limitations, utilizing the FSO technique, which can be combined in fiber network, would be the alternative to complete the wireless data link. presents the scenario of schematic architecture for the proposed WDM-FSO network. In the presented FSOsystem, the multiple continuous-wave (CW) WDM wave-lengths are emitted simultaneously from the head-end (HE)site and then through the WDM multiplexer launch into each FSO line termination (LT). The WDM wavelengths can bemodulated in the OL to generate FSO signals and connect to corresponding optical wireless units (OWUs) for delivering bidirectional FSO traffics simultaneously. As illustrated in the LT can be integrated in the optical network unit (ONU) of PON network for confidential data link viabidirectional FSO connection. Moreover, the bidirectional.

WDM-FSO transmission is emitted from the corresponding OWU placing at the properly location for the dedicated point-to-point data connection.shows the proposed bidirectional WDM-FSO transmission architecture. In the HE site, there are five CW WDM lasers (LD1 to LD5) can be connected to the 2×4 WDMmultiplexer (WDM1) via seven 1×2 and 50:50 optical couplers (CPRs), as illustrated Hence, the LD1 (λ1) and LD2 (λ2), LD2 (λ2) and LD3 (λ3), LD3 (λ3) and LD4 (λ4), and LD4 (λ4) and LD5 (λ5) are connected to the input ports ‘‘1’’,‘‘2’’, ‘‘3’’ and ‘‘4’’ of 2×4 WDM1, respectively. Besides based on the characteristic of 2×4 WDM1, the wavelengths of λ1, λ2, λ3 and λ4; and λ2, λ3, λ4 and λ5 would be exported from the output port ‘‘a’’ and ‘‘b’’ of WDM1, respectively,as seen in Thus, the output wavelengths of λ1 to λ4 and λ2 to λ5 would enter the corresponding 1×4 WDM2 and 1×4 WDM3 in the left and right side.

Then, the left wavelengths of λ1 to λ4 would arrive at the corresponding FSO LT. Next, the WDM signals pass through a length of single-mode fiber (SMF1) and then into each OWU for FSO transmission, as shown in Fig. 2. The LT is consisted of the polarization controller (PC), Mach- Zehnder modulator (MZM), optical circulator (OC) and a photodiode (PD). The OWU is constructed by an OC and two fiber-based collimators (COLs) for bidirectional FSO connection. Next, the left WDM wavelengths are emitted via COL and pass through a length of free space transmission and could be received by the right COL. Thus, the WDM FSO signals would launch into a length of SMF2 and then into the right LT for FSO demodulation. Similarly, the WDM wavelengths of λ2 to λ5 would be emitted from the right side of the proposed FSO system architecture and detected in the left LT, as seen Here, the distributed lengths of SMF1 and SMF2 can be set for each OWU according to the practical environmental location. In accordance with the proposed WDM-FSO architecture,the five WDM wavelengths can result in four pairs of FSO LTs and OWUs. Hence, a pair wavelength of λ1 and λ2, λ2 and λ3, λ3 and λ4, and λ4 and λ5 are used for the OWU1 to OWU4 to produce the bidirectional FSO transmissions, respectively. In the demonstration, due with confidentiality for end user. to the bidirectional FSO traffic with different downstream and upstream wavelengths in fiber transmission, the proposed WDM-FSO system also can avoid the Rayleigh backscattering (RB) interferometric beat noise [18]. As a result, the proposed WDM-FSO system not only can use the same multiple WDM signals for bidirectional FSO traffic from the HE site,but also can mitigate the RB beat noise. In addition, the proposed FSO system also can lead to exclusive connection the experimental setup of the proposed WDM- FSO transmission for proof of concept. In the experiment, a tunable laser source (TLS) connects to the PC and 10 GHz MZM. Adjusting the polarization status of PC can maintain the optimal output power of WDM-FSO signal after through the MZM. The TLS is used to switch the different output wavelength for the demonstration of each WDM-FSO signal. Here, the WDM wavelengths of 1530.33, 1532.29,1534.25, 1536.22 and 1538.19 nm are applied in the measurement for executing the bidirectional FSO transmissions, respectively. displays the measured output wavelength spectra of five WDM-FSO signals. The output power of each wavelength is nearly 10 dBm before entering the MZM. In the experiment, the insertion losses of MZM and PC are 7 and 1 dB. To enhance the output power of each WDM channel,an erbium- doped fiber amplifier (EDFA) can be applied in the HE site. The saturation output power maximum noise figure (NF) of EDFA are 13 dBm and 6 dB over the wavelength range of 1528.0 to

1562.0 nm. Here, to avoid the nonlinearity effect of FSO signal in fiber link, a variable optical attenuator (VOA) is also utilized for power adjustment properly.

Thus, the observed output power of each FSO wavelength is ~7 dBm after leaving MZM to prevent the nonlinearity,as seen in Fig. 3. Then, a 10 Gbit/s on-off keying (OOK) modulation signal with a pattern length of 215−1 is applied on the MZM for FSO data traffic. The FSO wavelength would experience through the SMF1, COL, and a 5 m long free space transmission length. And then the wireless FSO signal could be collected by a COL and into a 10 GHz PIN- based PD after passing through a length of SMF2. In the experiment, the divergence angle of COL is 0.016◦An optical pre-amplifier, which is consisted of an EDFA and a VOA, can be utilized to enhance the detected power sensitivity of FSO signal for measuring the bit error ratio (BER) performance in the Rx site. In addition, the observed insertion losses, including the atmospheric absorption and coupling loss, between two COLs are 3.2, 3.0, 3.0, 2.8 and 2.6 dB, respectively, when the FSO wavelengths of1530.33, 1532.29, 1534.25, 1536.22 and 1538.19 nm are utilized.

The FSO wavelength of 1530.33 nm is selected for measurement. The wireless FSO transmission length is set at 5 m.When the COL is rotated by θ angle, then it would cause a corresponding vertical displacement (d or −d) in the receiver (Rx) side, as illustrated in Fig. 6(a). As mentioned above, the observed power sensitivity of 1530.33 nm is−23.5 dBm at the BER of 1×10−9 Hence, Fig. 6(b) presents the obtained BER measurement under the different displacements of 0 to 1.19 cm when the SMF1 and SMF2 are 0 and 0 km and the θ is rotated from 0◦to 0.137◦, respectively. With the increase of displacement d (rotation angle θ) slightly, the observed BER performance also becomes worse. When the displacement d is 0 and 1.19 cm, the measured BERs are error free(≤1×10−9) and 1×10−3, respectively. When the θ is larger than 0.137◦,the BER cannot be observed in this measurement. It means that the obtained sensitivity power would be below −30.5 dBm (BER<3.8×10−3). Here, to keep the obtained BER within the FEC threshold, the available tolerance of ±1.19 cm displacement (θ = ±0.137◦) in theRx side is permissible in the experiment. According to the above results, the rotation angle would affect the detected

FSO power in the PD. With increasing the rotation angle of COL slowly, the detected power would also reduce. Hence, if the detected sensitivity power can meet the FEC limit no matter how long the wireless transmission lengths, the measured FSO signal also should be demodulation of five FSO signals with 10 Gbit/s OOK modulation after 5 m long free space transmission, when the SMF1 and SMF2 are set at the 0 km [back-to-back (BtB)] and 0 km, 25 km and 0 km, and 0 km and 25 km, respectively. As indicated in Figs. 5(a) to 5(b), the observed power sensitivities of 1530.33, 1532.29, 1534.25, 1536.22 and 1538.19 nm are −30.5,−29.6, −27.6, −25.6 and −24.2 dBm, −35.2,−33.3, −30.0,−26.9 and −25.9 dBm, and −35.3, −32.9,−31.1, −28.7 and −26.2 dBm, respectively, under the forward error correction (FEC) level, which means the BER =3.8×10−3

Thus, the maximum and minimum power budgets are 42.3 and 31.2 dB in the experiment. In the measurement, as the FSO wavelength moves toward longer wavelengths, the obtained corresponding sensitivity will gradually deteriorate. Moreover, we observe that the measured BER performance after through 25 km SMF is better than that of the BtB status, as exhibited in Figs. 5(a) to 5(c). This is because the chirp parameter of MZM is −0.7. The negative chirp could pre compensate the chromatic fiber-dispersion of FSO signal and result in a better BER performance after through a 25 km SMF transmission length. Moreover, the observed results of Fig. 5(c) are also better than that of Fig. 5(b). The obtained sensitivity of FSO signal could determine the free space transmission length under an optimal optical system design. In the measurement, we select 1535±5 nm wavelength range for the proof of concept in WDM-FSO transmission. Certainly,we can also utilize the other WDM wavelengths for FSO traffics in the proposed network architecture. Moreover, based on the measured results of Fig. 5, when the FSO signal gradually moves toward long wavelengths slowly, the obtained power sensitivity would also increase.

According to the previous study [19], the RB beating noise would decrease the signal to noise ratio (SNR) of ~6.5 dB when same wavelengths were used for bidirectional traffic. The lower SNR would result in poor BER performance. Moreover, as the length of the fiber decreases gradually, the effect of RB interference would also decrease [19]. If the SMF length is less than 25 km, the RB beat noise would be reduced.

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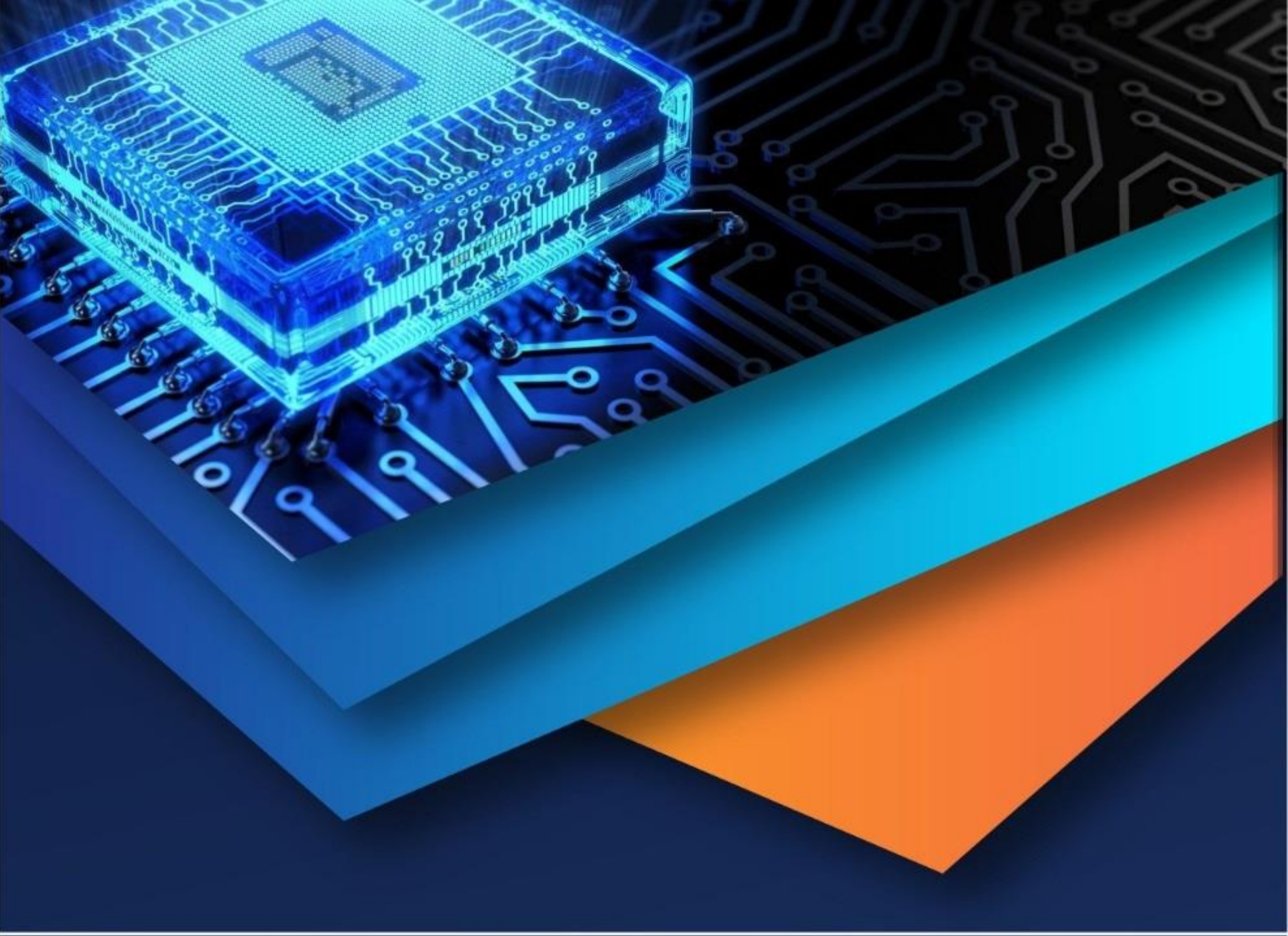

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