Indonesian Journal of Electrical Engineering and Computer Science
Vol. 12, No. 1, October 2018, pp. 428~432
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v12.i1.pp428-432

Impact of Combine Dithering and Modulators to Mitigate Noise in Radio Over Fiber System

Fakhriy Hario, Eka Maulana, Hadi Suyono, Rini N Hasanah, Sholeh H Pramono
Department of Electrical Engineering Faculty of Engineering, Brawijaya University,
Jl Veteran Malang-East Java, Indonesia

Article Info

Article history:

Received May 22, 2018
Revised Jul 23, 2018
Accepted Jul 30, 2018

Keywords:

Dithering
GVD
Modulator MZM
Radio over fiber
SPM

ABSTRACT

A well-prepared Radio over Fiber (RoF) is a technology that combines two transmission technologies, radio and optical fiber transmissions. The study focused on the characteristics and problems of the optical fiber medium. One of the problems in the optical fiber is the effect of nonlinear characteristic, which caused by the high light intensity in the optical fiber core with extended interaction area in a single mode fiber (SMF). This characteristic reduces the output width and creates a pulse broadening. The nonlinear characteristics discussed in this study focused on SPM (self-phase modulation) and GVD (Group Velocity Dispersion). To overcome the nonlinear problems, this study presented a method to make the noise-resistant transmitted signal and improve the optical fiber power range. The fundamental of this study was developing similarities of previous studies regarding nonlinearity in the optical fiber. The results show that the use of two modulators combined with the amplification generated the signal with smoother spectrum, which means that the spectrum distribution was more uniform. There was 61.5 % increase of the peak power of the output signal after amplification using an optical amplifier.

Corresponding Author:

Fakhriy Hario,
Department of Electrical Engineering Faculty of Engineering,
Brawijaya University,
Jl Veteran Malang-East Java, Indonesia.
Email: ekamaulana@ub.ac.id

1. INTRODUCTION

Nonlinear mitigation in RoF schemes can be done using several concepts and methods [1]-[3]. Some of these concepts and methods include the use of frequency and phase dithering and the use of external components and direct modulator [4]-[6]. Several types of nonlinear effects considered in the referred studies are SPM, XPM, FWM, SBS, and SRS [7]. However, some weaknesses can be developed using a new contribution presented in this study.

We proposed new concepts and system schemes, which was the development of a RoF scheme by integrating an existing system based on a method and modification of some components. The contribution of the new concepts and system schemes was the development of dithering technique methods and some components on RTO and receiver detection. The realization of the contribution was intended to generate output signals that are more resistant to nonlinear effects, especially SPM and GVD [8]-[9]. Mostly the problems of nonlinear in previous works focus in characteristic laser. That is intresting problem to research. In [10] the research showed also contellation diagram based on dithering and processing signal. This papepr will develop and detail focus in nosie charateristic reduce on nonlinear condition. Characteristic will be focus in measurement output of moodified modulators and signal processing (dithering). In addition, the method could produce a more efficient system in terms of minimum power transmission usage and the appropriate maximum input power. Lastly, it could increase the range of fiber optic channel span by considering nonlinear effects. Finally, focus of this research are elaboration the new model of Radio of Fiber using dithering technique and several parallel modulators and Local Oscillator (LO) in receiver to mitigate noise.

2. RESEARCH METHOD

The proposed design OFDM-RoF system. In the transmitter, two modulators LiNbO3 MZM have injected signal $S_{RF}(t)$ composed from CW (Continuous-Wave) laser. CW laser used to produce a continuous wave optical signal. Signal from CW laser direct to process by using 16 QAM component modulation and OFDM 12 modulators with a data rate 10 Gbps and frequency of 193.1 THz. Signal optic from modulators will combined to the analog signal of dithering technique. The source of system dithering is sinusoidal wave signal with the high frequency of 200 THz and modulated in the frequency deviation of 100 GHz. It is selected causes high frequency uses to long span transmission. Dither was used to control the signal high amplitude of a frequency modulator. In a receiver, Local Oscillator (LO) power and varying linewidth to mitigate effect of linewidth and power receiver to systems. Output information equation of the system shown by:

$$y = h_1(t) * f_{NL}\big(x(t)\big) = h_1(t)\, f_{NL}\big(r_g(t) + d(t)\big) \quad (1)$$

$h_1(t)$ is the impulse response of the filter $H_1(j\omega)$.In high frequency case, the dither signal, denoted as $d_H(t)$ is assumed to have a frequency much higher than the maximum frequency component of the input signal $r_g(t)$. The simulation of proposed scheme here used Optisystem version 13.0.

This method proposed modified of blok modulators and adding some signal to generate and pump signal. These are for mitigate nonlinear characteristic in optical fiber. The mathematical model of nonlinear will proposed using Schrodinger mathematical model. After analysis of nonlinear, the proposed system will reduce in minimize nonlinear as a noise problem. The proposed reseacrh will be description in Figure 1 using block diagram.

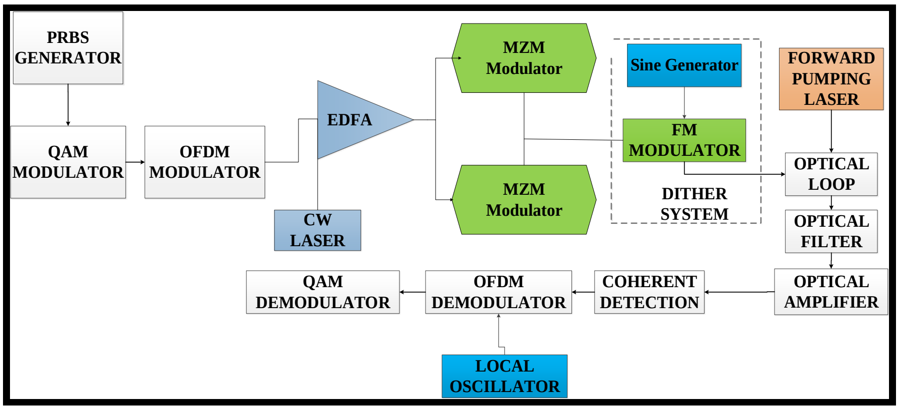


Figure 1. Scheme modified of RoF-OFDM using dual MZM LiNb03

3. RESULTS AND ANALYSIS

The next measurement and observation aimed to compare the output of the single modulator MZM $LiNbO_3$ and the use of two $LiNbO_3$ MZM modulator. The next measured variable was the output of the gain after the two modulators.

Figure 2(a) shows the output spectrum of one modulator with the power of -26 dBm and the dynamic range of 70 dB. Meanwhile, Figure 2(b) illustrates the output spectrum of the combined two modulators. The generated power was slightly increased to reach -20 dBm, with the narrower dynamic range of 64 dB. The output signal of the combined two modulators then amplified using an optical amplifier.

The amplification output is displayed in Figure 3 with the increasing power that reached -10 dBm and the dynamic range of 40 dB. The obtained FWHM value also increased with the maximum value reached -38 dBm. Figures 2(a) and (b) show that the spectrum distribution became more uniform, which means it can contain more information. In terms of power increase, there was 23% peak power increase of the output signals of two modulators compared to one modulator. However, there was 61.5 % increase of the peak power of the output signal after amplification using an optical amplifier. The dynamic range is a calculation of the maximum range of a measurement range, or the power level that limits the maximum width of spectrum that can be calculated.

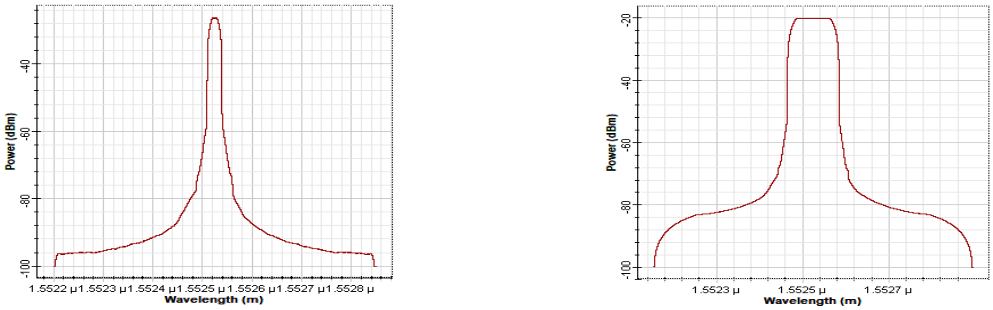


Figure 2. (a) Output spectrum of one modulator, (b) Output spectrum of the combined two modulators

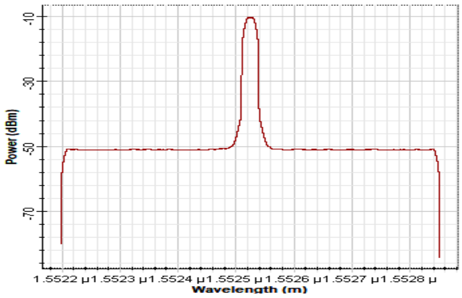


Figure 3. Spectrum after amplification using two modulators.

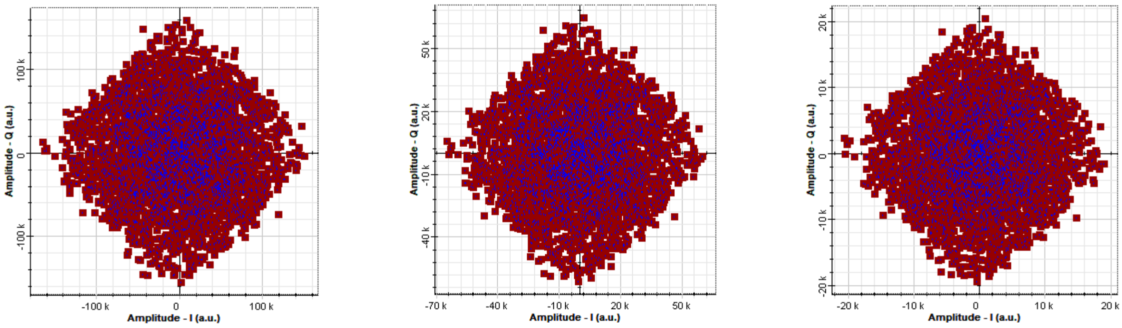
The narrower dynamic range gives the better spectrum resolution. In terms of the dynamic range, the results show that the use of two modulators combined with the amplification generated the signal with smoother spectrum, which means that the spectrum distribution was more uniform. The measurements of the received power used with and without the proposed scheme (component mitigation) are summarized in Table 1.

Table 1. Comparison of the Received Power with and Without the Component Mitigation Scheme

(dBm)	Before Mitigation			After Mitigation		
	10 km	50 km	100 km	10 km	50 km	100 km
		(dBm)			(dBm)	
-8	104.22	88.23	68.23	127.41	119.41	109.41
-6	108.45	92.45	72.44	129.4	121.4	111.4
-4	112.78	96.78	76.77	131.39	123.39	113.4
-2	117.24	101.25	81.24	133.37	125.37	115.37
0	121.84	105.84	85.83	135.33	127.33	117.33
2	126.54	110.54	90.53	133.37	125.37	115.37
4	131.26	115.26	95.25	139.2	131.18	121.18
6	135.91	119.91	99.91	141.07	133.04	123.03

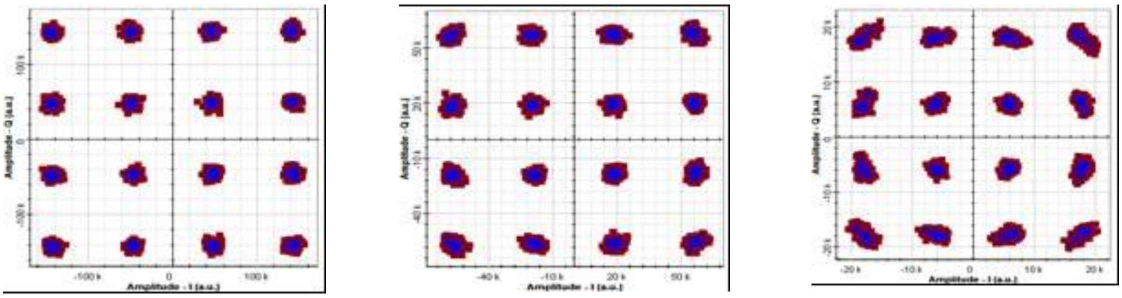
Signals from the ideal transmitter were represented as constellation points assuming the ideal condition in the receiver. However, some imperfection (distortion, noise, loss, and others) caused the real constellation points to deviate from the ideal location. One step in the demodulation process is the phase shift, which creates an I-Q (In-phase–Quadrature) flow that can be used as the reliable estimated parameters for the ideal transmitted signal.

Figure 4 illustrates that the constellations had canonic properties, which means that the separation between constellations was maximum. The generated constellation was the representation of the impulse output of a system. Figure 5 has a signal representation and energy that were denser than the optimal information and structure set, which shown by the higher energy and amplitude than the constellation in Figure 4.



(a) (b) (c)

Figure 4. The constellation of one modulator with dithering-pumping and LO in the optical fiber with the length of a) 10 km, b) 50 km, and c) 100 km



(a) (b) (c)

Figure 5. The constellation using the proposed scheme in the optical fiber with the length of a) 10 km, b) 50 km, and c) 100 km

The generated constellation had a canonical form, which is a condition that represents the resulting coordinate transformation is in the optimum separation (maximum separation). The resulting error is small and the correct signal position correctly is easily detectable. In canonical conditions, the received signal is more associated with the working efficiency of the system.

In a mathematical sense, the canonical form of the standard way of repressing the object as an experiment of a mathematical function. In some general fields, the canonical form determines the unique representation of each object. Meanwhile, the normal form determines its shape without any unique requirement. The canonical form of positive integers in the decimal representation is a finite sequence of numbers that do not originate from zero.

The canonical differential form can be attributed to Hamilton's mechanical theory. The theory was developed as a reformulation of classical mechanics (classical mechanics is part of the physics of the forces acting on an object). The objects in classical mechanics can be statistical, kinematics, and dynamics (objects that move by force influences). The formulation of classical mechanics is essentially contributed to the formulation of statistical and quantum mechanics. One particle with mass m represents the Hamilton function in a one-dimensional system, with the Hamiltonian representing the total energy of the system which is the sum of the kinetic energy and the potential energy.

4. CONCLUSION

The small linewidth correlates with the coherent value and produces a large optical spectrum. Optical power spectral densities can be attributed to fixed optical frequency intervals (measured in Terahertz), or at wavelength intervals (in nanometer units). This suggests that the shorter wavelengths in nanometers have the value in the scale of Terahertz. The consequence is that the peak position of the spectrum with large bandwidth can be significantly dependent on the power density. The dependence refers to the frequency or wavelength interval. Linewidth lasers greatly affect the coherent temporal, the coherent time, and the coherence length. Time coherence is a common form to determine the length of coherence.

The coherence length is a function of coherence time multiplied by the vacuum velocity. Time coherence can be used to measure the degree of temporal coherence in the light. In other coherence types, the coherent length can be used to measure the coordinate level of temporal coherence as the length of propagation (propagation time). This is necessary because in this process, coherence decreases significantly. It is defined as the time coherence multiplied by the constant speed of light. A narrow or limited linewidth emulates from phase noise if the phase drift (an unlimited constant or ever-changing process) is infinite (phase fluctuations bounded at intervals with small phase values causing the linewidth value to be zero and causing noise on some sidebands). The drift of the resonator length can then contribute to the linewidth quantity and can make its nature depends on the measurement of time. This shows that linewidth equipped with spectral form can provide comprehensive information. The information contains the purity of a laser light spectral (this happens usually in lasers that dominate frequencies with low-frequency phases).

REFERENCES

[1] M. Xue, S. Pan, and Y. Zhao. Optical Single-Sideband Modulation Based on a Dual-Drive MZM and a 120° Hybrid Coupler. *Journal of Lightwave Technology*. 2014; 32 (19): 3317-3323.

[2] Y. Wang, J. Yu, X. Li, Y. Xu, N. Chi, and G. K. Chang. Photonic Vector Signal Generation Employing a Single-Drive MZM-Based Optical Carrier Suppression without Pre-coding. *Journal of Lightwave Technology*. 2015; 33 (24): 5235-5241.

[3] T. Kanesan, W. Pang, Z. Ghassemlooy, and C. Lu. *Impact of Optical Modulators in LTE RoF Systems with Nonlinear Compensator for Enhanced Power Budget*. Proc. of Optical Fiber Communication Conference and Exposition and the National Fiber Optic Engineers Conference, California, United States. 2013; 1-3.

[4] T. Kanesan, W. Pang, Z. Ghassemlooy, and C. Lu. Investigation of Optical Modulators in Optimized Nonlinear Compensated LTE RoF System. *Journal of Lightwave Technology*. 2014; 32 (23): 1944-1950.

[5] T. Kanesan, W. Pang, Z. Ghassemlooy, and J. Perez. Optimization of Optical Modulators for LTE RoF in Nonlinear Fiber Propagation. *IEEE Photonics Letters*. 2012; 24 (7): 617-619.

[6] T. North and M. Rochette. Analysis of Self-Pulsating Sources Based on Regenerative SPM: Ignition, Pulse Characteristics and Stability. *Journal of Lightwave Technology*. 2013; 31 (23): 3700-3706.

[7] Z. Jiao, R. Zhang, X. Zhang, J. Liu, and Z. Lu. Modeling of Single-Section Quantum Dot Mode-Locked Lasers: Impact of Group Velocity Dispersion and Self Phase Modulation. *Journal of Lightwave Technology*. 2013; 49 (12): 1008-1015.

[8] F. H. Partiansyah, A. Susanto, I. W. Mustika, S. M. Idrus, and S. H. Purnomo. Dithering Analysis in an Orthogonal Frequency Division Multiplexing-Radio over Fiber Link. *International Journal of Electrical and Computer Engineering*, 2016; 6 (3): 1112-1121.

[9] F. Khair, F. H. Partiansyah, *I. W. Mustika*, and B. Setiyanto. Performance Analysis of Digital Modulation for Coherent Detection of OFDM Scheme on Radio over Fiber System. *International Journal of Electrical and Computer Engineering*. 2016; 6 (3): 1086-1095.

[10] Fakhriy Hario, I.Wayan Mustika, Adhi Susanto, Sholeh Hadi, Sevia M Idrus. A Novel Scheme for Orthogonal Frequency Division Multiplexing-Radio over Fiber Based on Modulator and Dithering Technique: Impact of Self Phase Modulation and Group Velocity Dispersion. *International Journal of Intelligent Engineering and Systems*. 2017; (4): 117-125.