Simulation and Analysis of a Full Duplex DWDM RoF System Using Optimized Phase Modulator and an OADM

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Abstract- We've proposed a full duplex Dense Wavelength Division Multiplexing (DWDM)Radio over Fiber (RoF) system using an optimized phase modulator and an optical add drop multiplexer. Phase modulated carrier is suppressed using an optimized phase modulator. That is an optimized phase deviation is given to a phase modulator to suppress the central carrier of the modulated signal. An optical add drop multiplexer is used to add or drop specific channel at a particular base station. Performance of the system is analyzed. This system is compared with one which is not using an optimized phase modulator. The eye diagram and bit error rate performance of the base station and central station has been analyzed.

Keywords: Radio over Fiber (RoF),Dense Wavelength Division Multiplexing (DWDM).

I. Introduction

Optical mm wave generation through radio over fiber is an emerging technology in the area of communication Simplification of Remote access points (RAPs) is the key advantage of this technique. It can be considered as the solution to future broad band wireless access network [1]. In Radio over Fiber (RoF) system, a microwave signal is available at the input, which is then modulated over light and transmitted over fiber towardsremote radio access point (RAP). Performance of this system depends on so many factors like modulation format, transmitted power and optical fiber length and type etc. The power being transmitted after modulation can be reduced to some extend by suppressing the optical carrier. There by we can improve signal to noise ratio.

Carrier suppression through enhancing the modulation index of the phase modulator has already been proposed in [2]. i.e., tuning the modulation index will help to decrease the Bessel amplitude of the central carrier of the modulated signal. High value of the modulation index will increase the side band power, which in turn affects the performance of the system when it is used in wave length division multiplexing (WDM) networks.

In this paper, a full duplex Dense wave length division multiplexing (DWDM) RoF system, which makes use of anoptimized phase modulator and an add drop multiplexer is proposed. This system makes use of an optimized phase modulator instead of Mach-Zehnder Modulator (MZM) which results in reduced power transmission of generated mm wave. The power is deducted by suppressing the central carrier of phase modulated wave. Three different Interleaver filters are used to separate first order side bands of each channel. Interleaver filter is a type of optical filter which separate incoming spectrum into two complimentary spectrums, whose separation is entirely different from the input spectrum. The principle and working of interleaver filter has already been proposed in [3], [4]. It is the best solution when Fiber brag grating (FBG) fails due to temperature variation. Optical add-drop multiplexer (OADM) is a device used in wavelength division multiplexing systems for multiplexing and routing different channels of light into or out of a construction of optical network. Two OADMs are used here to represent two base stations.The received signal shows better correlation with the input signal

In addition to this system, a single channel RoF system with and without phase modulator and interleaver filer is presented for analyzing the transmittedpower and fiber range.

II. Operating Principle

A phase modulated optical signal has side bands at its harmonics. The power level of each side band and central carrier is a function of modulation index. By changing the modulation index, it is possible to decrease the carrier power to some extent. Phase modulated signal can be generated by simply phase modulating the continuous wave light source. The output of the phase modulator can be expressed in terms of Bessel function [2].

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$$E'_{out} = E_0 e^{j\omega_0 t} e^{j\beta \cos\omega_m}$$

$$= E_0 \sum_{n=-\infty}^{\infty} (j)^n Jn(\beta) e^{j(\omega_0 + n\omega_m)t}$$

$$\approx E_0\{J_0(\beta)e^{j\omega_0 t} + J_1(\beta)e^{j[(\omega_0+\omega_m)t+\pi/2]}$$

$$- J_1(\beta)e^{j[(\omega_0-\omega_m)t-\pi/2]}$$

$$- J_2(\beta)e^{j[(\omega_0+2\omega_m)t]} - J_2(\beta)e^{j[(\omega_0-2\omega_m)t]}\} \quad (1)$$

Where, E_0 and ω_0 are the amplitude and frequency of carrier wave, β is the modulation index, $J_n(\beta)$ is the Bessel function of first kind order 1, and ω_m is the angular frequency of driving signal..

Phase modulation index can be expressed in terms of half wave voltage [5]

$$\beta = (V_e/V_\pi)\,\pi/2 \quad (2)$$

Where, V_π is the half wave voltage of phase modulator, V_e is the amplitude of electrical signal voltage.

We've the phase deviation of the phase modulator

$$\Phi = (V_e/V_\pi)\,\pi\text{, in radian} \quad (3)$$

i.e., by changing the phase deviation of optical phase modulator, we can suppress the central carrier of the optical carrier. The depth of the carrier suppression depends on the modulation index value. We can achieve a carrier suppression of 41dB if a phase deviation of 276° is applied to the phase modulator. This optimized phase deviation is used in proposed DWDM system, so as to suppress the central carrier of each channel.

Here a central station with three channels and two base stations are considered to analyze the performance of optimized phase modulator in a DWDM RoF system.

III. EXPERIMENTAL SET UP

A 2.5 Gbps pseudorandom binary sequence (PBRS) signal with a word length of2^5-1 is used to modulate a transmitter at 193.1THz and is then fed into a PM driven by a 20-GHz sinusoidal wave. A phase deviation of 276° is applied to phase modulator to achieve carrier-suppressed optical up-conversion.A single channel system is shownin Fig. 1. For a DWDM system, three different channels with spacing of 100GHzare used to transmit three different data streams. Experimental set up for DWDM system is shown in Fig. 2.

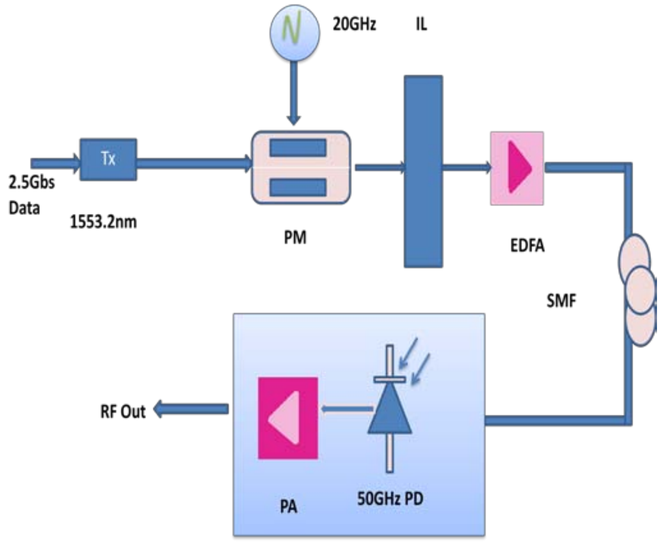

Fig. 1. Experimental model of single channel RoF system

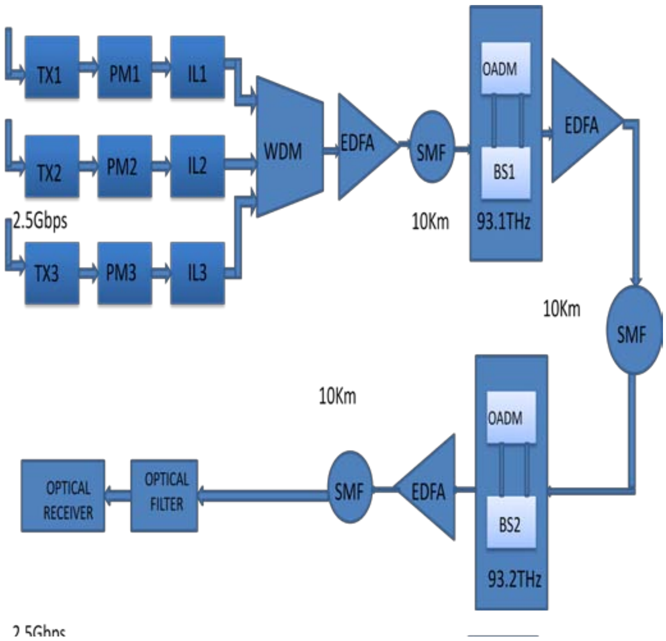

Fig. 2. Experimental model of proposed system

IV. SIMULATION AND RESULT

Simulation is done in optisystem 11 software. Optisystem is a powerful software tool for designing optical communication system.It can be used to design optical communication systems and simulate them to determine their performance by giving various component parameters.

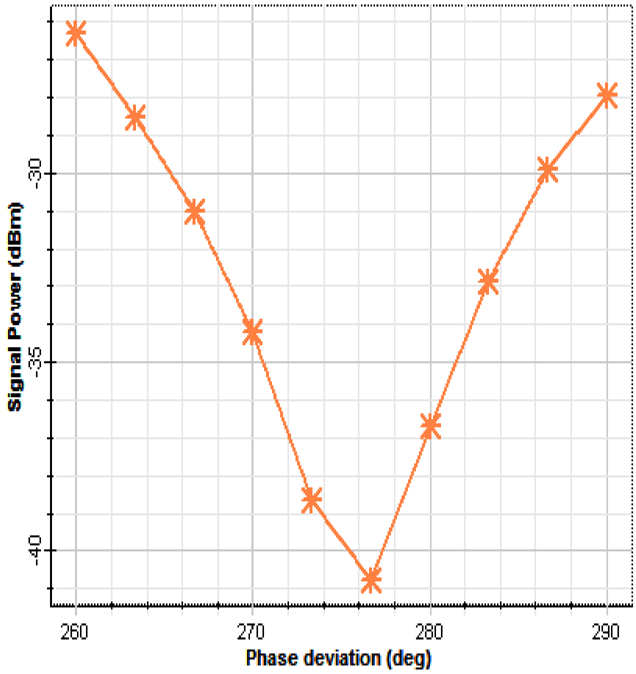

Fig. 3.Phase deviation versus carrier power

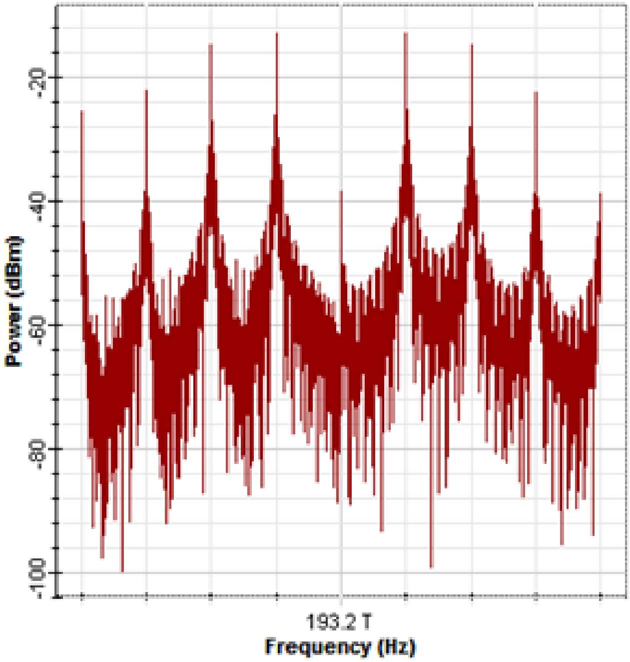

Fig. 5.Carrier suppressed spectra of channel 2

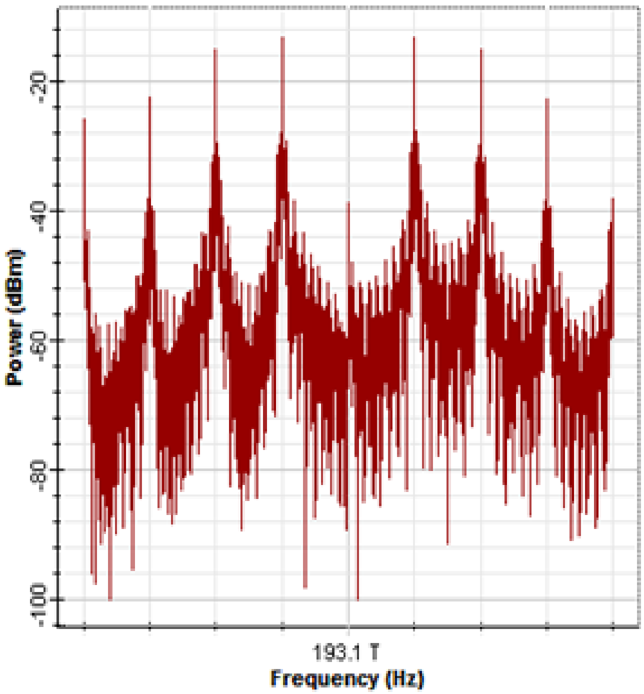

Fig. 4.Carrier suppressed spectra of channel 1

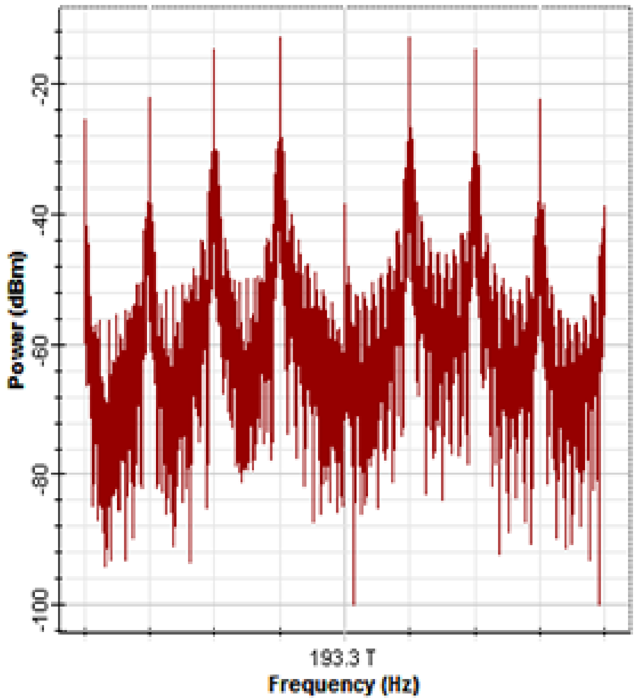

Fig. 6.Carrier suppressed spectra of channel 3

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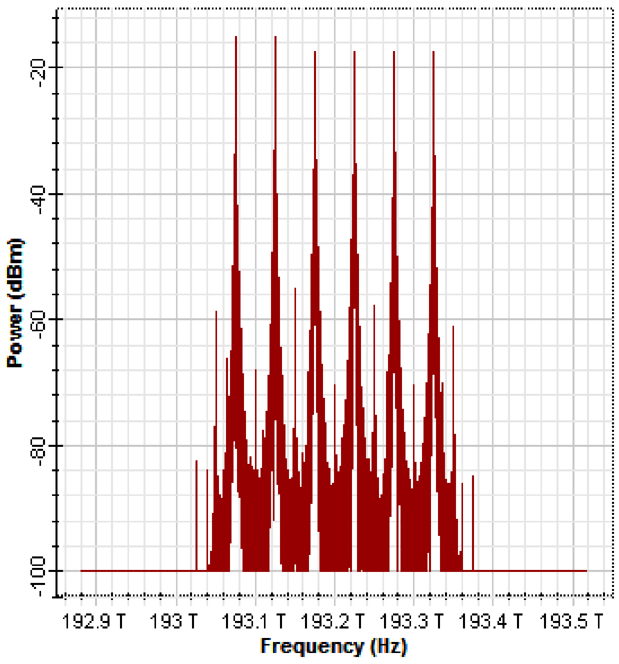

Fig. 7. Spectra of multiplexed signal

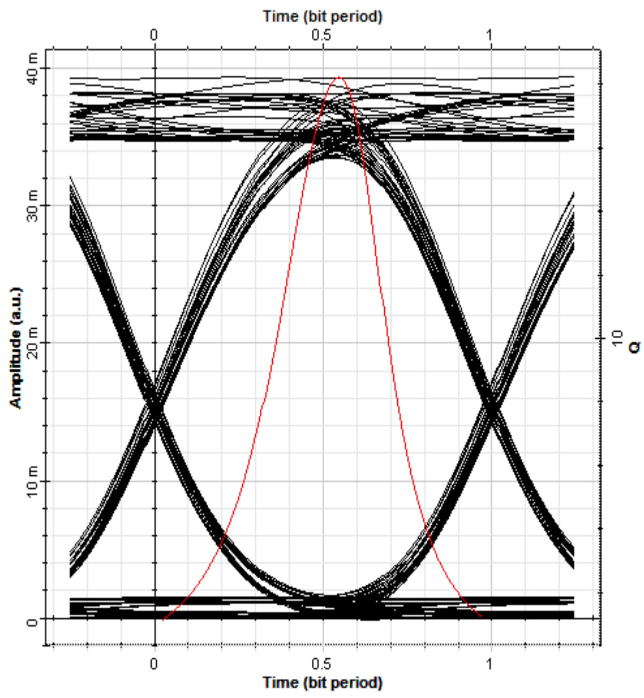

Fig. 9.Eye diagram of downlink channel of BS 2

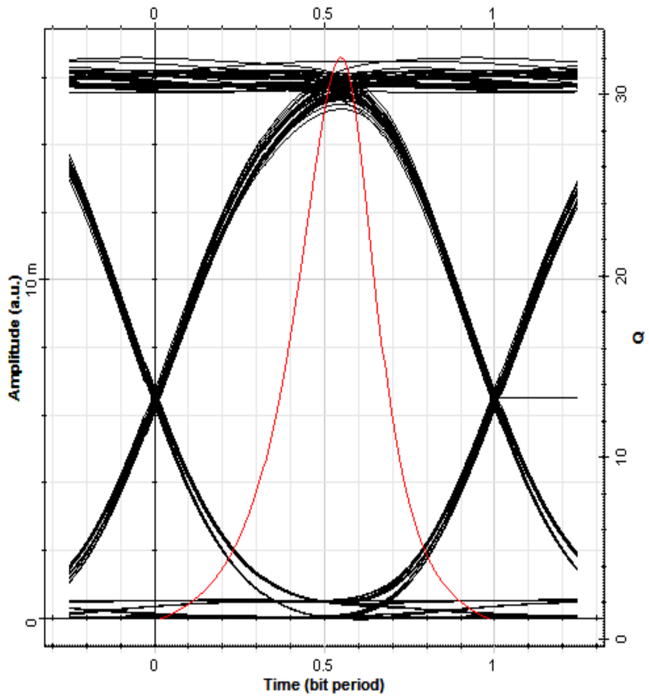

Fig. 8. Eye diagram of downlink channel of BS 1

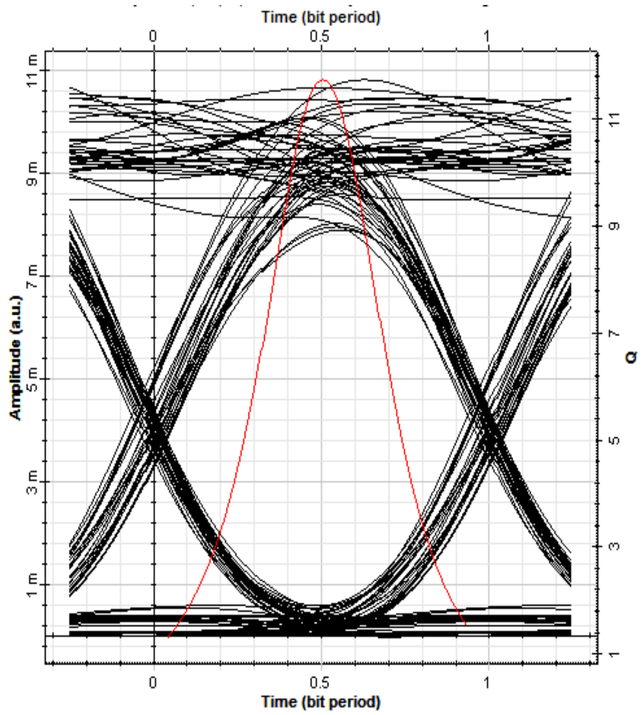

Fig. 10.Eye diagram of uplink channel of BS 1

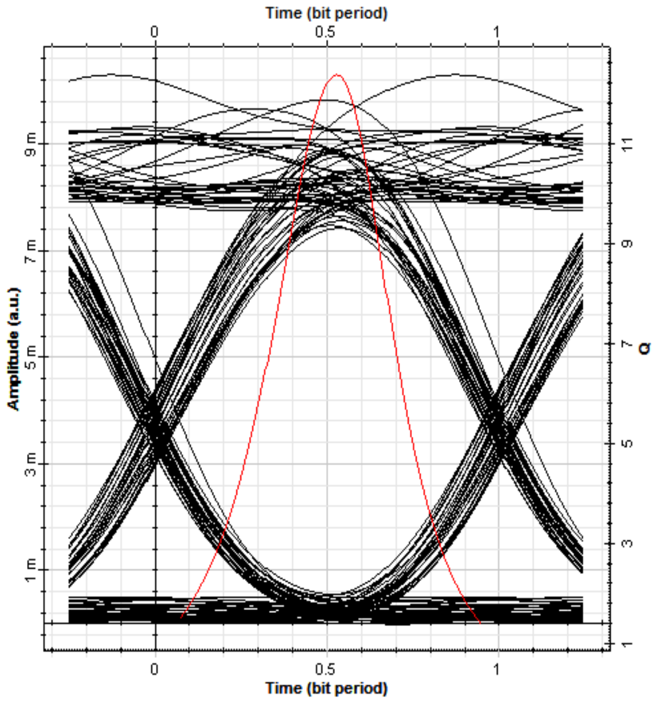

Fig. 11. Eye diagram of uplink channel of BS 2

The carrier signal power at the output of phase modulator versus phase deviation value is plotted in figure 3. It is found that a 276□ the carrier is suppressed up to 41 dB. The output spectra of phase modulator of each channel are shown in figures 4, 5, and 6. It is clear from the figures that the central carrier of the modulated signal is almost fully suppressed. The multiplexed spectra of three channels are shown in figure 7. The eye diagrams of data received at base station 1 and 2 are shown in figures 8 and 9 respectively. The eye diagram of data received from the uplink channel of BS1 and BS2at central station is shown in figures 10 and 11 respectively. The difference in the BER of two base stations is mainly due to the difference in distance travelled. More over each channel have different wave lengths and hence causes different dispersion as travels through the fiber.

Table 1 shows the comparison of single channel RoF system with and without employing phase modulator and interleaver filter. It is found that, after a 30Km transmission through single mode fiber (SMF) the signal quality of the RoF system with phase modulator and interleaver filter is comparatively less than that of other method. Even though the fiber transmission length is less the power saved is significant in this system. The total power output at the phase modulator after suppression of central carrier is 229µW. But in other case it is about 484µW. i.e, half of the power is saved by employing an optimized phase modulator for modulating 2.5Gbps data.

TABLE 1
COMPARISON OF SINGLE CHANNEL ROF SYSTEM WITH AND WITHOUT PM AND IL FILTER

Fiber length (in Km)	With PM and IL			Without PM and IL		
	Max.Q Factor	Min. BER	Eye diagram	Max.Q Factor	Min. BER	Eye diagram
5	81.5867	0	Excellent	92.9538	0	Excellent
10	60.677	0	Excellent	42.2108	0	Excellent
20	23.9719	2.19659×10^{-127}	Good	23.0889	2.78003×10^{-118}	Good
30	10.3055	2.8507×10^{-25}	Good	17.5142	4.59603×10^{-69}	Good
40	5.01106	2.38576×10^{-7}	Bad	10.9394	2.85639×10^{-28}	Bad
50	2.6697	0.00396674	Bad	7.34994	7.38232×10^{-14}	Bad

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V. CONCLUSIONS

A full duplex DWDM RoF system using an optimized phase modulator and optical add drop multiplexer is proposed, simulated and analyzed using optisystem 11.Good eye diagram and low BER is achieved for 5Km fiber transmission from central station. Even though OADM effectively adds/drops the desired channel to/from the DWDM feeder network, successive cascading of these interfaces in the Central Office (CO) and the remote nodes (RNs) may cause significant performance degradation and impose limitations in network dimensioning.If the multiplexing and de-multiplexing functionality in the CO and the RNs can instead be combined into a single device, cost-effective architectures with reduced complexity can be realized.

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